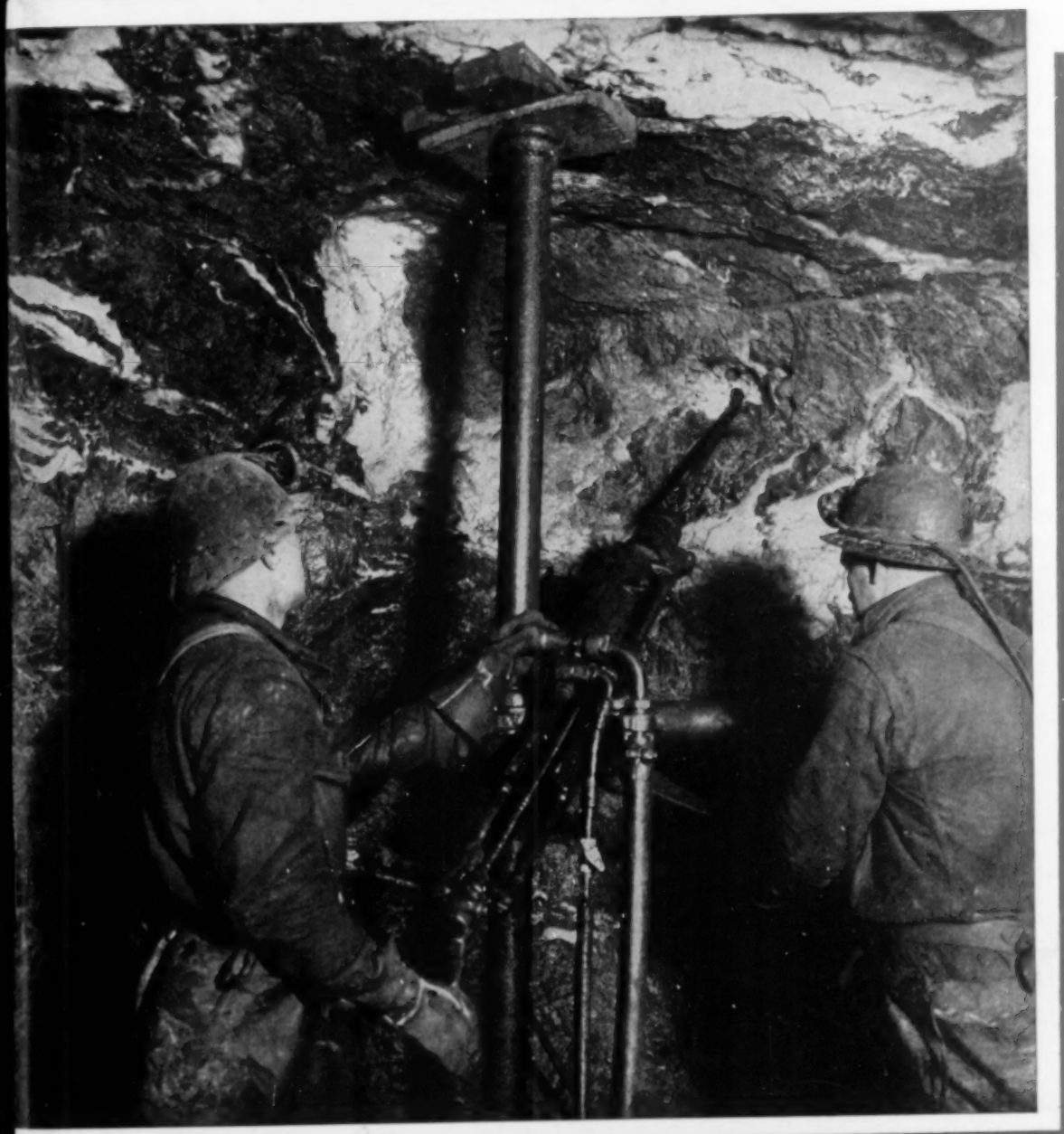
Compressed Air Magazine

OCTOBER 1943



STARTING THE DRILL ROUND

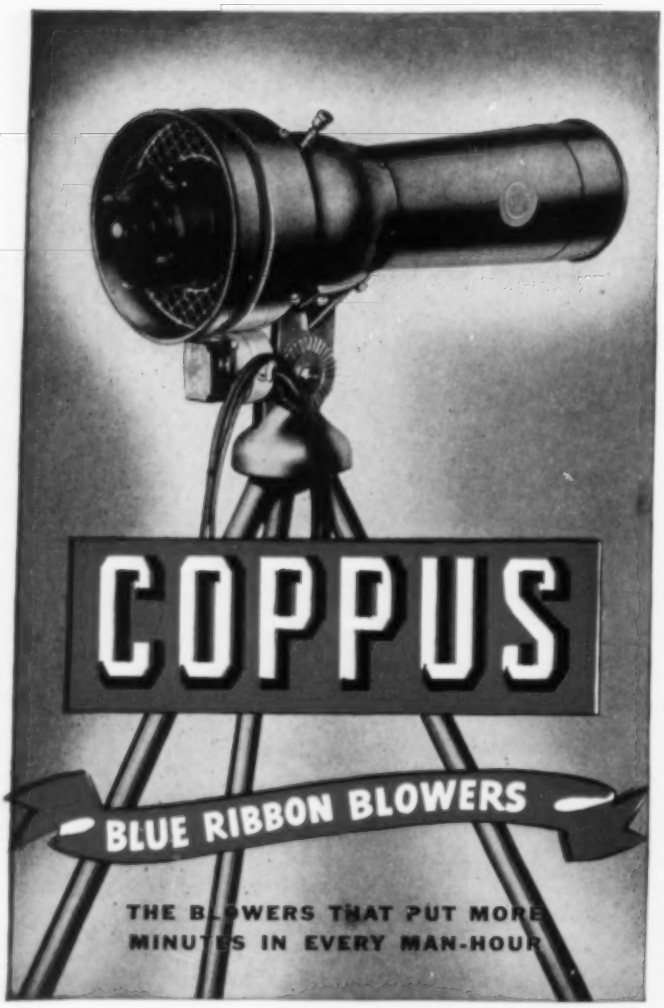
Drifting in a Metal Mine

VOLUME 48 • NUMBER 10

NEW YORK • LONDON

New Strength through Air

WORKERS HAVE MORE WAR PRODUCTION "DRIVE" WITH A COPPUS BLOWER OR HEAT KILLER NEARBY



Thousands of cases prove that a man can do more work where it's cool and comfortable than where heat and bad air are continually sapping his energy.

In these cases, Coppus "Blue Ribbon" Blowers and Exhausters have earned their salt, bringing renewed energy, skill and morale to men working near furnaces . . . in tanks . . . in underground cable manholes . . . around hot processes.

Portable, adaptable for special purposes, each one built with Coppus "Blue Ribbon" precision and strength, they are putting more working minutes into every war-essential man-hour—more and better production every day!

CABLE MANHOLE AND TANK VENTILATORS — BOILER MANHOLE BLOWERS AND EXHAUSTERS — HEAT KILLERS — SHIPHOLD VENTILATORS . . . DESIGNED FOR YOUR INDUSTRY — ENGINEERED FOR YOU

MAIL THIS COUPON To Coppus Engineering Corp., 360 Park Avenue, Worcester, Mass. Sales offices in THOMAS' REGISTER. Other "Blue Ribbon" Products in SWEET'S CATALOG.

PLEASE SEND ME INFORMATION ON SUPPLYING FRESH AIR TO MEN WORKING:

- ☐ in tanks, tank cars, drums, etc.
- ☐ in underground cable manholes.
- ☐ in aeroplane fusilages, wings, etc.
- ☐ on coke ovens.
- ☐ on steam-heated rubber processes.
- ☐ on boiler repair jobs.

COOLING:

- ☐ motors, generators, switchboards.
- ☐ wires and sheets.
- ☐ general man cooling.
- ☐ around cracking stills.
- ☐ exhausting welding fumes.
- ☐ stirring up stagnant air wherever men are working or material is drying.
- ☐ drying of walls, sheets, etc., after treated with coating material.

NAME .....

COMPANY .....

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CITY .....

(Write here any special ventilating problem you may have.)

THE HEART OF EVERY PROTECTOMOTOR

MODEL D
INTAKE FILTER

MODEL DS
INTAKE
SILENCER FILTER
(Sectional View)

MODEL CPH
AIR LINE
FILTER
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MODEL CPHS
AIR LINE
FILTER
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1. Provides **positive dry type filtration.**
   - (a) cleanable (washable)
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2. Provides **largest possible active filtering area** in relation to space occupied.
   - (a) ideal for dust storm areas
   - (b) low resistance to air flow
3. Provides **maximum resistance to pulsation** through rigid design.

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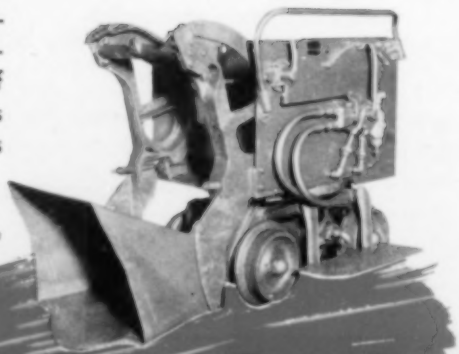
VICTORY BEGINS HERE

Victory begins in the deep earth where nature has locked the much needed war metals, copper, zinc, iron, nickel, tungsten, lead, molybdenum; all these and many others are the elements which make the sinews of Victory. The task of releasing these metals from their underground origin is now being performed at an amazing speed. Huge production of metal ores has made it possible for our Commanders-in-chief and their military staffs to plan for certain Victory. But underground where Victory begins the "Eimco Loader" has been one of the miracles of modern mechanics that has made production records possible. In practically every mine in the United States that produces war metals the Eimco Loader is on a twenty-four hour shift.

A large staff of Eimco Loader field men are available for advice, service and consultation. Join the parade of users!



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THE EIMCO CORPORATION, SALT LAKE CITY 8, UTAH

NEW YORK, 120 BROADWAY — SACRAMENTO, 1217 7TH ST.

CHICAGO, 111 W. WASHINGTON ST. — EL PASO, MILLS BUILDING

Goblins of the Stratosphere

LOOKING like men from Mars, the faces and heads of high-altitude fliers are protected against the rarefied atmosphere . . . by masks of plastic supplied with oxygen from high-pressure storage tanks. The production of oxygen for filling these tanks is an interesting wartime use of compressors.

To maintain compressors at top operating efficiency, not only for filling oxygen tanks, but for compressing air in thousands of industrial plants and mines throughout the U. S., operators everywhere are lubricating them with Texaco.

Texaco Alcaid, Algol and *Ursa Oils* assure wide-opening, tight-closing valves, free piston rings, open ports, clear air lines, maximum service life between inspections and overhauls, fewer repairs and replacements.

So effective have Texaco lubricants proved in increasing output that they are definitely preferred in many important fields, a few of which are listed at the right.

A Texaco Lubrication Engineer will gladly cooperate in the selection of the most suitable lubricants for your equipment. Just phone the nearest of more than 2300 Texaco distributing points in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.

THEY PREFER TEXACO

★ *More Diesel horsepower on streamlined trains in the U. S. is lubricated with Texaco than with all other brands combined.*

★ *More locomotives and railroad cars in the U. S. are lubricated with Texaco than with any other brand.*

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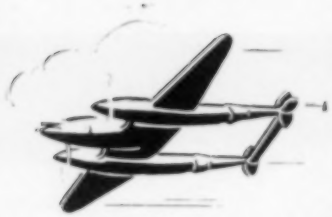
TEXACO

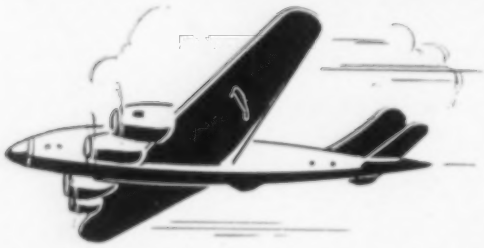
TEXACO Lubricants

FOR ALL AIR COMPRESSORS AND TOOLS

TUNE IN THE TEXACO STAR THEATRE EVERY SUNDAY NIGHT – CBS ★ HELP WIN THE WAR BY RETURNING EMPTY DRUMS PROMPTLY



Tens of Thousands of feet altitude and still on the ground!



Supercharged engines are playing a tremendous part in our high-altitude fighting and bombing. The superchargers must be absolutely right for the job—which means careful testing.

A leading manufacturer was faced with the problem of duplicating altitude conditions at the exhaust of the gas turbines used for driving their superchargers. Specifically, the problem involved the use of vacuum apparatus to handle large volumes of hot exhaust gases at suction pressures corresponding to tens of thousands of feet in the air.

After studying all phases of the problem with Ingersoll-Rand, the manufacturer installed several large steam jet ejectors—largely because of the reliability, simplicity, compactness, and ease of operation secured with such apparatus.

Repeat orders indicate the success of this solution of an important war production problem.

May we cooperate with you in the application of vacuum apparatus?

Ingersoll-Rand
11 BROADWAY, NEW YORK, N. Y.

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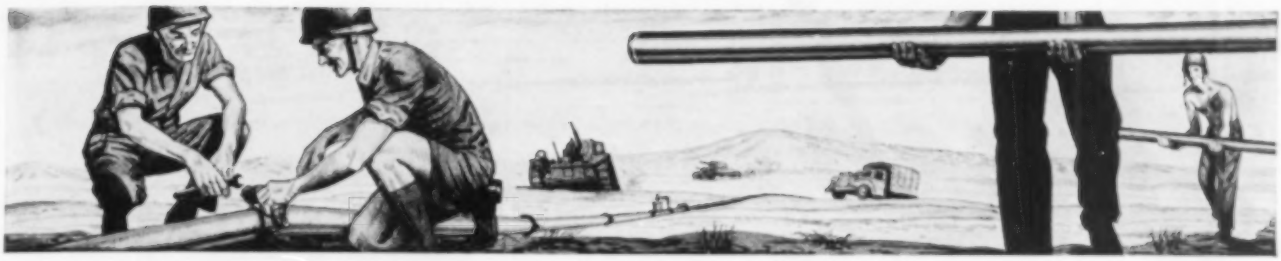
CENTRIFUGAL PUMPS • CONDENSERS • COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES



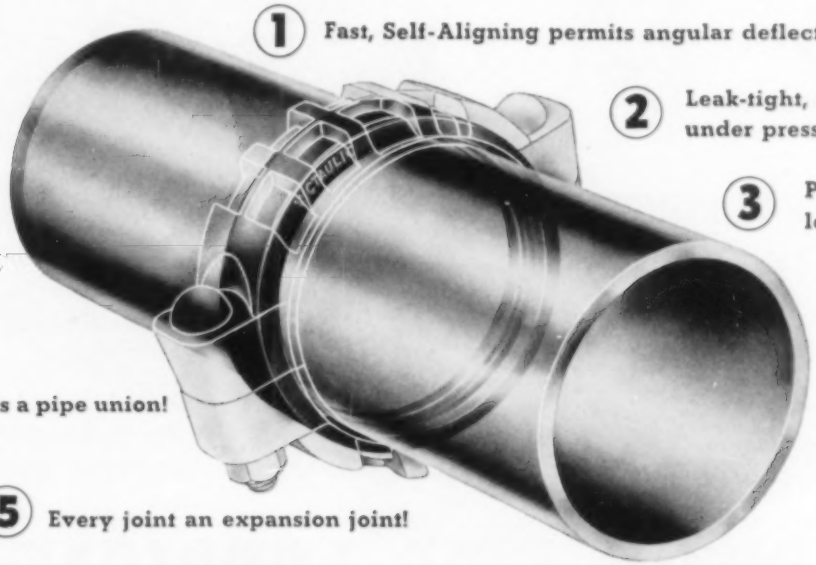
BLITZ PIPELINES

One of the potent weapons in the Allied blitz campaigns in North Africa and Sicily turned out to be Victaulic coupled portable pipelines that could be laid by unskilled or regular Army personnel at the rate of 10 to 30 miles a day so oil, gasoline, or water could keep pace with swiftly advancing troops. Specially designed pipe, grooved for Self-Aligning Victaulic Couplings, was used. Victaulic is the fastest known way of coupling pipe . . . and Victaulic gives you all these other basic advantages . . .

1 **Fast, Self-Aligning permits angular deflection!**

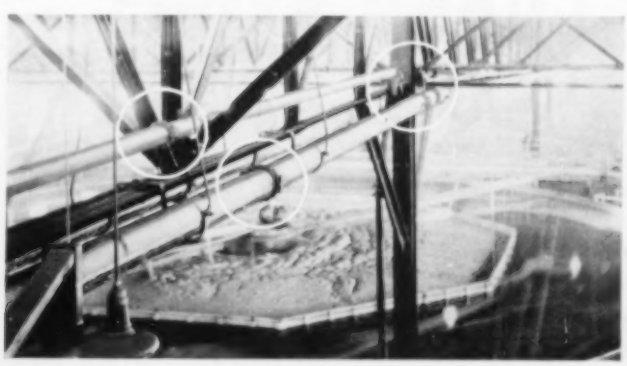
2 **Leak-tight, self-sealing under pressure or vacuum!**

3 **Positive mechanical lock of pipe lengths!**

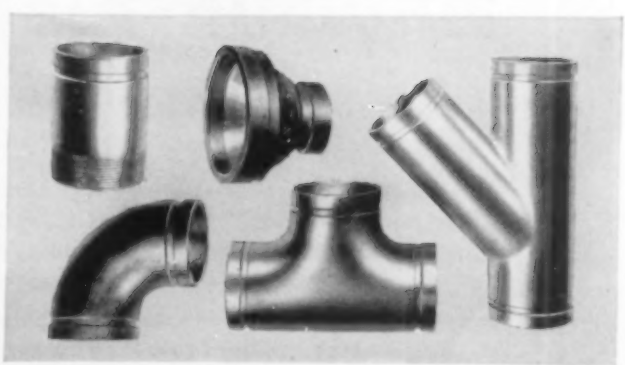


4 **Every joint is a pipe union!**

5 **Every joint an expansion joint!**



DOLLAR SAVING FEATURES FOR INDUSTRIAL CONSTRUCTION! Installed faster and with less labor than any other method. A small socket wrench is the only tool needed. Victaulic joints are compact, flexible. Provide substantial savings in space and weight. Temporary lines can be salvaged 100 per cent. Maintenance is nil on permanent jobs.



VICTAULIC FULL-FLOW FITTINGS! A new line of redesigned pipe fittings to eliminate undue frictional losses! Engineered with long easy sweeps to reduce the possibility of clogging to an absolute minimum. A real contribution to greater efficiency in conducting fluids and gases in pipe systems.

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VICTAULIC

SELF-ALIGNING PIPE COUPLINGS AND FULL-FLOW FITTINGS

Available soon for your permanent files . . . a new easy-to-use Victaulic Catalog and Engineering Manual. Reserve your copy now!

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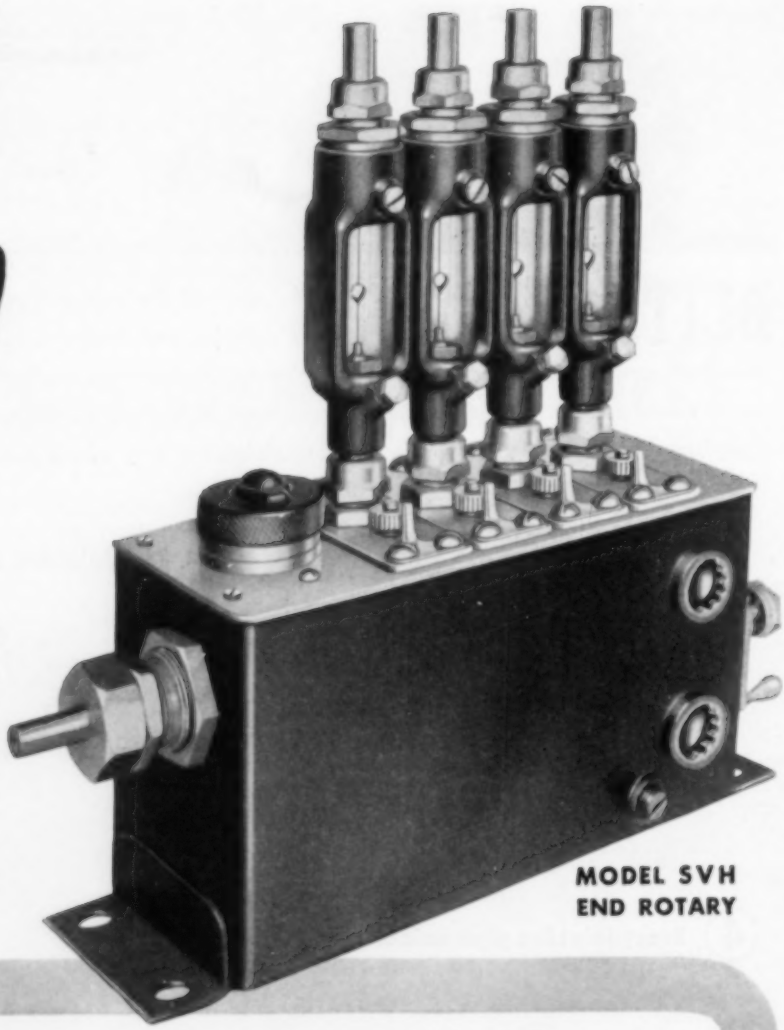
Mail to nearest address: VICTAULIC COMPANY OF AMERICA, 30 Rockefeller Plaza, New York 20, N. Y.; Victaulic Inc., Los Angeles 14, California; Victaulic Co. of Canada, Ltd., Toronto. I-G

Fresh Oil



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END ROTARY

FED UNDER PRESSURE
DROP BY DROP

MADISON-KIPP LUBRICATORS

the most dependable method of lubrication ever developed

There are Madison-Kipp lubricator models for every Fresh Oil application. There are 6 models and each can be varied to suit the requirements in drive type and location, in the number of feed outlets, rate of feed and pumping pressure.

Madison-Kipp specializes in original standard equipment lubricators. When you buy new machinery it will pay you to specify Madison-Kipp . . . the most dependable method of lubrication ever developed.

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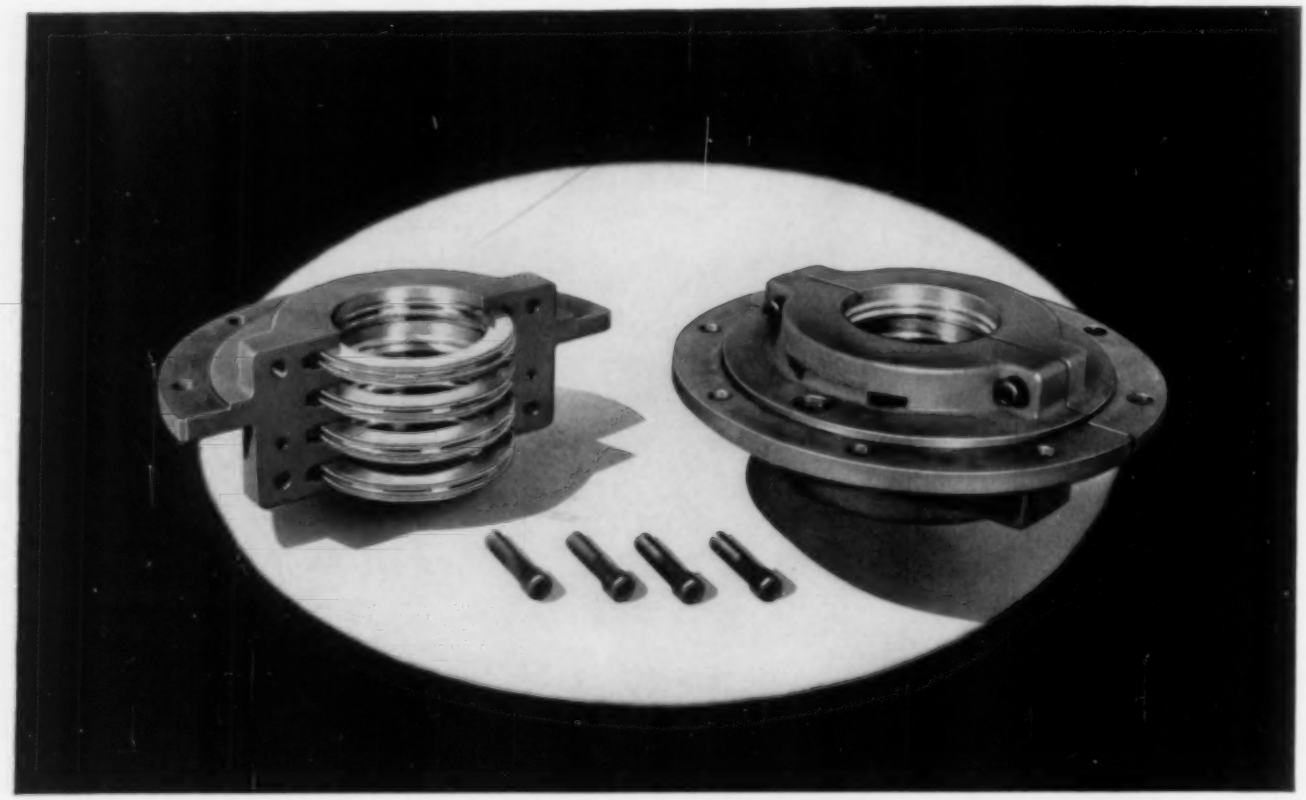

IMPROVED OIL CONTROL PACKINGS

FOR ENCLOSED FRAME ENGINES AND COMPRESSORS

Under war's expanded demands for Metallic Packings, COOK has not only multiplied production, but has also developed many new types—packings to meet 750°F. superheated steam—to withstand the corrosive action of various gases—to meet the special requirements of the synthetic ammonia and synthetic rubber industries—packings for the engines of Liberty and Victory Ships and "special" ships by the hundreds.

Among these developments are oil control packings, like the one shown above—packings which meet and satisfy the varied oil control requirements of enclosed crank case type Diesel, gas and steam engines, air and gas compressors, and pumps—packings that keep crank case oil out of the cylinders and prevent oil formations and carbon deposits and resulting stuck piston rings, valve failures, fouled inner coolers and receivers—packings that keep compressed air or gas free of oil—packings that pay their way many times over in oil and trouble saved.

All of these new developments have proved up in service—demonstrating again and again the effectiveness of COOK design, materials and production.

You too may have a packing problem that calls for something different—something better. If so, our engineers are ready to serve you. And when you call in COOK, you get the benefit of 55 years' experience manufacturing exclusively Metallic Packings for Pistons and Rods.

C. LEE COOK MANUFACTURING CO., Incorporated, Louisville, Kentucky. Branches and Representatives: Baltimore, Boston, Chicago, Cleveland, Houston, Los Angeles, Mobile, Montreal, New Orleans, New York, Portland, Ore., San Francisco, Seattle, Tulsa.

"Sealing Pressures Since 1888"

COOK'S METALLIC PACKINGS

2 WAYS TO CUT DRILLING COSTS

1 USE DETACHABLE BITS

Detachable bits drill faster than ordinary steel bits—and even work well in soft or muddy ground. Yet they are safe for use in stopes and raises. There is more time for drilling because steel doesn't have to be carried back and forth on the job. Steel shop costs are reduced—so are nipping charges. A simple forming and gauging operation is all that is necessary to put a detachable bit back into service. No forging or re-tempering is needed.

2 KEEP THEM PROPERLY GROUND

For best results, be sure to use grinding wheels that are specifically made to hold their shape and to cut fast, free and cool . . . wheels that give you accurate gauge and form with longer tool life between grinds and lowest cost per grind. Every grinding wheel today is a "Weapon for Production." Use it wisely.

Every hour this war is shortened will save $12,000,000. The lives it will save are priceless. Let's get it over with—quickly.

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THE CARBORUNDUM COMPANY • NIAGARA FALLS, N. Y.

MANUFACTURERS OF GRINDING WHEELS, COATED ABRASIVES, SUPER REFRACTORIES, HEATING ELEMENTS

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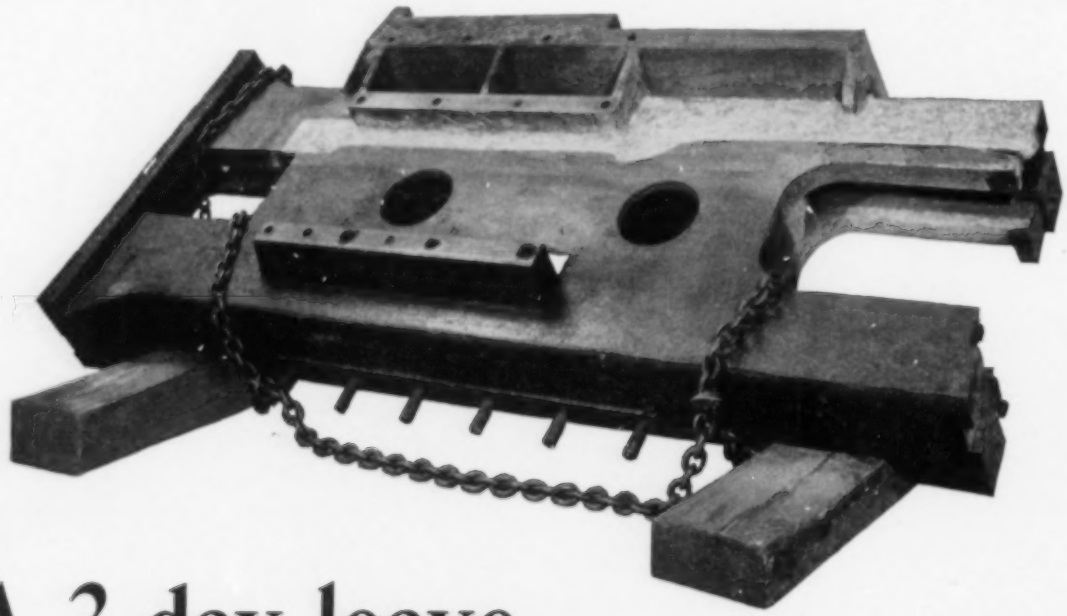


A 3-day leave instead of 10 months A.W.O.L.

Thanks to Bronze Welding

Out of action for some ten months might well have been the fate of this cast iron column of a press producing 75 mm. shell cases. For that's about how long it would take to get a replacement these days.

But bronze welding came to the rescue. Although the 8-ft. high, 6-ton heavy casting had cracked for a distance of 7 feet, the fracture was quickly repaired in the shop by the Super Arc Welding Company, Detroit, Mich. 20 man-hours for preparation, 48 man-hours for welding, 400 lbs. of Tobin Bronze* Welding Rod—and the column was back on the job. That was nearly a year ago. Today, the repaired press is still giving a good account of itself—instead of making shell cases—pressing out an important motor part for army trucks and armored cars.

*Reg. U. S. Pat. Off.

For speedy, wartime repair welding, never overlook the advantages of such rods as Tobin Bronze and Anaconda 997 Low Fuming. For complete information, write for the new edition of Anaconda Publication B-13. 4286A

BUY MORE WAR BONDS FOR VICTORY

ANACONDA

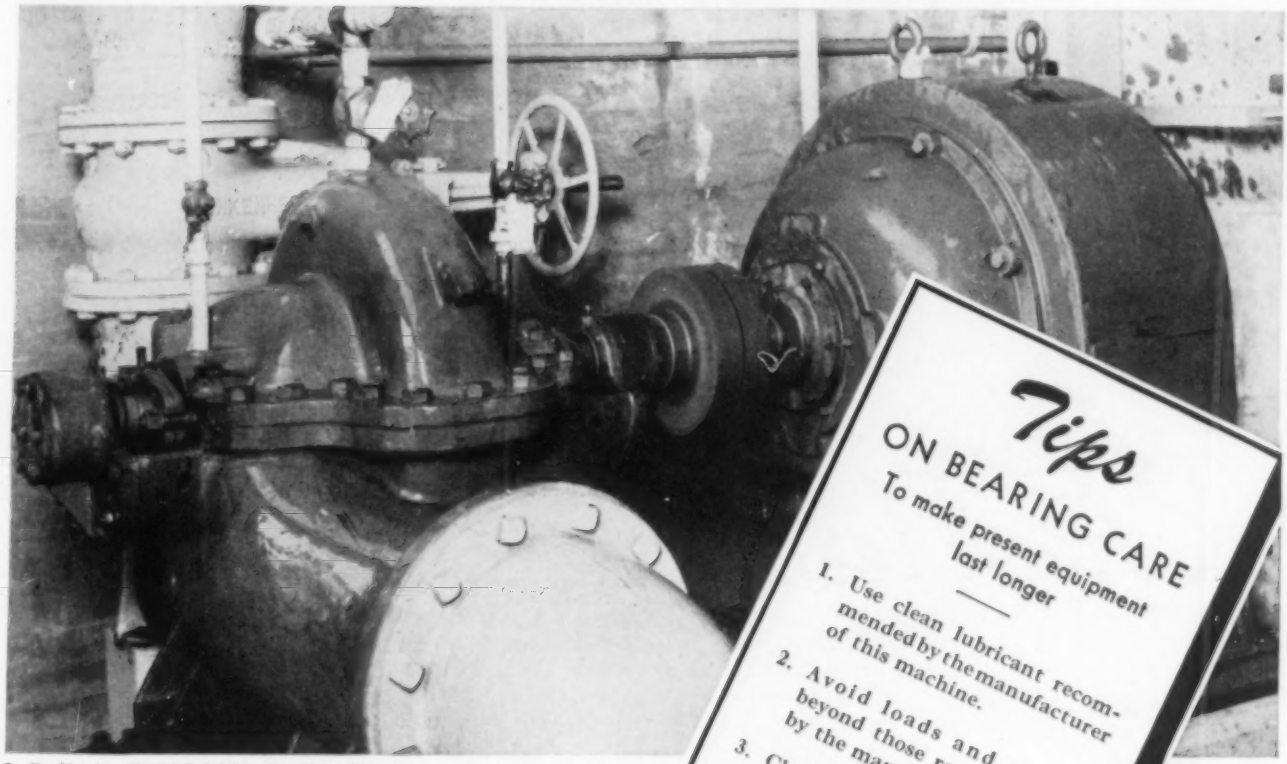
Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company • In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ontario

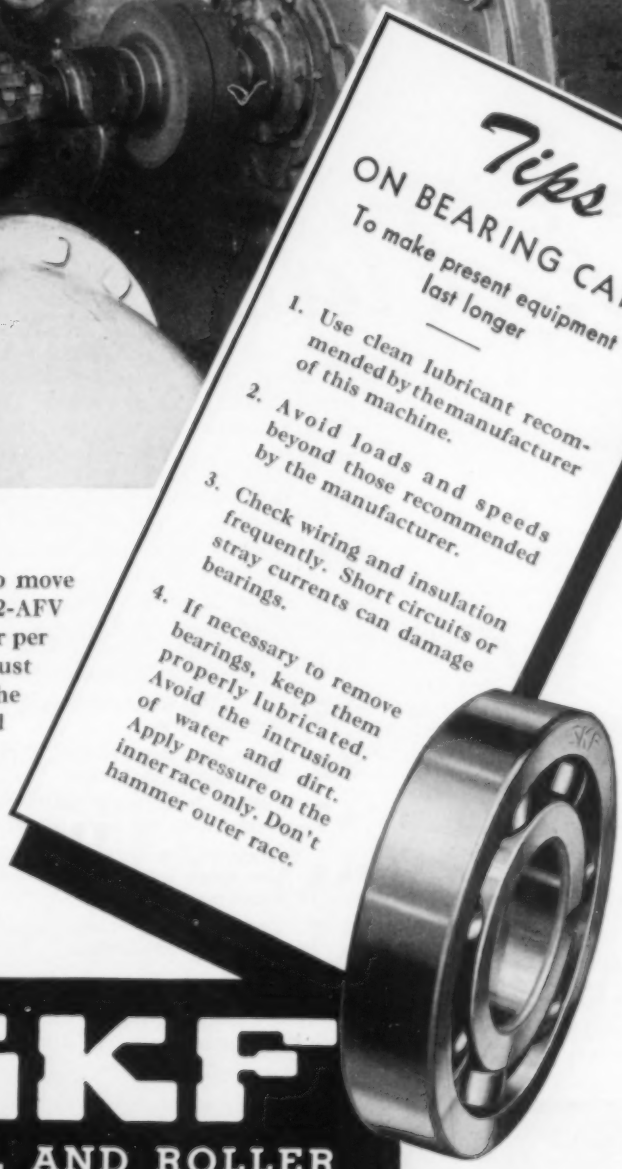
4500 gallons per minute

ON SKF BEARINGS



● *Built by* INGERSOLL-RAND CO.

The advantages that enable SKF Bearings to move freely and continuously while this size 12-AFV Cameron Pump transmits 4500 gallons of water per minute at 1150 r.p.m., 78-foot head, didn't just happen. Their lifetime close tolerances are the result of *good design.* The through-hardened steels of which they're made comes from the *proper selection of materials.* Their unvarying ability to take combined radial and thrust loads is the product of skilled craftsmen and precision machines. All advantages that enable users of these pumps to increase production for Uncle Sam. 5388


Tips
ON BEARING CARE
To make present equipment last longer
1. Use clean lubricant recommended by the manufacturer of this machine.
2. Avoid loads and speeds beyond those recommended by the manufacturer.
3. Check wiring and insulation frequently. Short circuits or stray currents can damage bearings.
4. If necessary to remove bearings, keep them properly lubricated. Avoid the intrusion of water and dirt. Apply pressure on the inner race only. Don't hammer outer race.
SKF

SKF
BALL AND ROLLER BEARINGS

ARMY E NAVY

SKF INDUSTRIES, INC., PHILA., PA.

Check list FOR BIG OUTPUT AND LOW MAINTENANCE

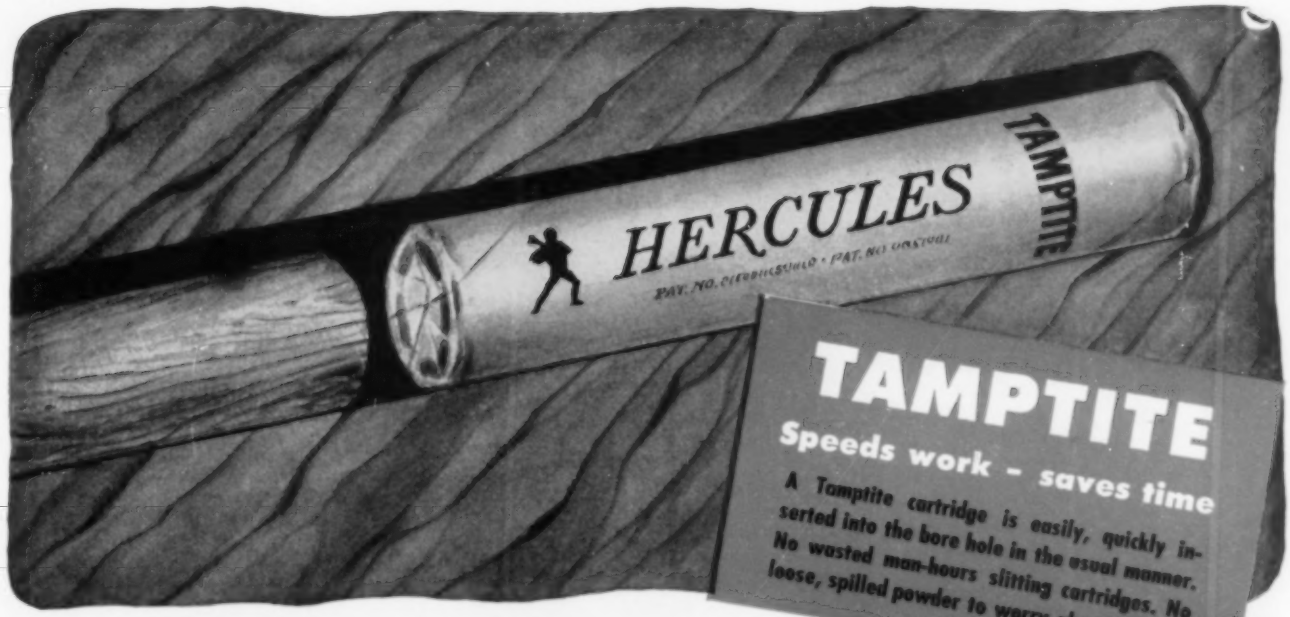
Ideas
to help YOU...
Keep your present excavators working and doing more to win the war
"RATIONED" HANDLE WITH CARE
Bucyrus-Erie
SOUTH MILWAUKEE, WISCONSIN

This 32 page, 5½ x 8¼" booklet, attractively illustrated and printed in two colors, is packed with practical, experience-tested suggestions on how to maintain maximum excavator production. Ask your Bucyrus-Erie excavator distributor for copies for your organization, or write us direct if you prefer.

Efficient job planning and preventive maintenance essential to continuous peak excavator performance demand constant vigilance. Check your operations against this list to make sure nothing important is being neglected:

1. Give your operator a chance to be a good one. Plan your job setup to move materials with the fewest motions in the shortest distance.
2. Analyze your cycle time, study delays and the percentage of your job efficiency at regular intervals.
3. Weigh monthly production records rather than daily. Steady output chalks up records that count.
4. Keep your excavator clean and inspect thoroughly at regular intervals. Stop troubles before they start, make repairs promptly.
5. Watch adjustments daily. Keep them right, always. This speeds output, saves repairs.
6. Keep lubricants *clean*. Dirt and grit build up into a grinding compound, sabotaging machinery.
7. Follow lubricating instructions religiously. Correct lubrication is best prescription for long life and trouble-free operation.
8. Drain engine crankcase while hot, flush out periodically. Keep fuel clean. Use clean soft water in radiator, flush regularly, don't put cold water in a hot engine.
9. Observe safety rules. Accidents are losses to everyone concerned. Safety first pays dividends.

Each one of these points is discussed in detail — there are over 100 specific suggestions — in a free booklet we hope will be helpful to your organization. It applies to all makes of excavators.


HERCULES
TAMPTITE
TAMPTITE
Speeds work – saves time
A Tamptite cartridge is easily, quickly inserted into the bore hole in the usual manner. No wasted man-hours slitting cartridges. No loose, spilled powder to worry about. Then—

TAMPTITE
Packs snugly
gives better breakage
You tamp a Tamptite cartridge in the usual manner. It packs evenly, snugly—leaves little air space—concentrates the charge for good breakage, faster mucking.

INCREASED TONNAGE, together with savings in valuable man-hours, can be gained by using your regular Hercules explosives in the new Tamptite* cartridges. Tamptite shells are convenient, easy to use. They eliminate the mess and trouble of slitting cartridges. They compress in the bore hole with a compactness that assures good breakage. And, the better breakage, of course, means easier, faster mucking. In fact, Tamptite speeds up your entire mining cycle. On your next order, specify Hercules in Tamptite cartridges.

*Reg. U. S. Pat. Off.

HERCULES EXPLOSIVES

HERCULES POWDER COMPANY
INCORPORATED
932 KING STREET • WILMINGTON • DELAWARE

A-99

30 TON PAYLOAD

...and built to carry it!

IRON ORE . . . that happens to be the critical payload in this case. We are proud to be playing our part in this important work.

Born of nothing more than rough sketches and verbal expressions, these bodies represent the ideas of a practical operating man and EASTON'S conception of how to accomplish his job. What EASTON has done for others can also be done for you.

EASTON has been a specialist in tailor-made trailers, dump trucks, mine cars, and electric lift trucks for years. If you're confronted with a materials handling problem, there's a good chance we can help you. Write to: Engineering Counsel, Easton Car & Construction Company, Easton, Pa.

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The Motorpump is truly a jack-of-all-trades, and master of them too, because of its compactness, sturdiness, efficiency and adaptability. Wherever liquids are being handled you will find Motorpumps—from refineries to ships and from the tropics to the arctic. • Motorpumps are available in a wide range of sizes and all can be installed easily without costly special foundations. Capacities range up to 1800 gpm and discharge heads up to 500 ft. • Thousands of them in all sorts of services are speeding the transport of liquids—liquids that keep machines on the job; liquids needed in processes; liquid foods; liquids that must be removed to keep mines operating, to speed construction work; etc. Ingersoll-Rand Company, Cameron Pump Division, 11 Broadway, New York, N. Y.

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CENTRIFUGAL PUMPS • CONDENSERS • OIL AND GAS ENGINES • ROCK DRILLS • AIR TOOLS • TURBO-BLOWERS • COMPRESSORS

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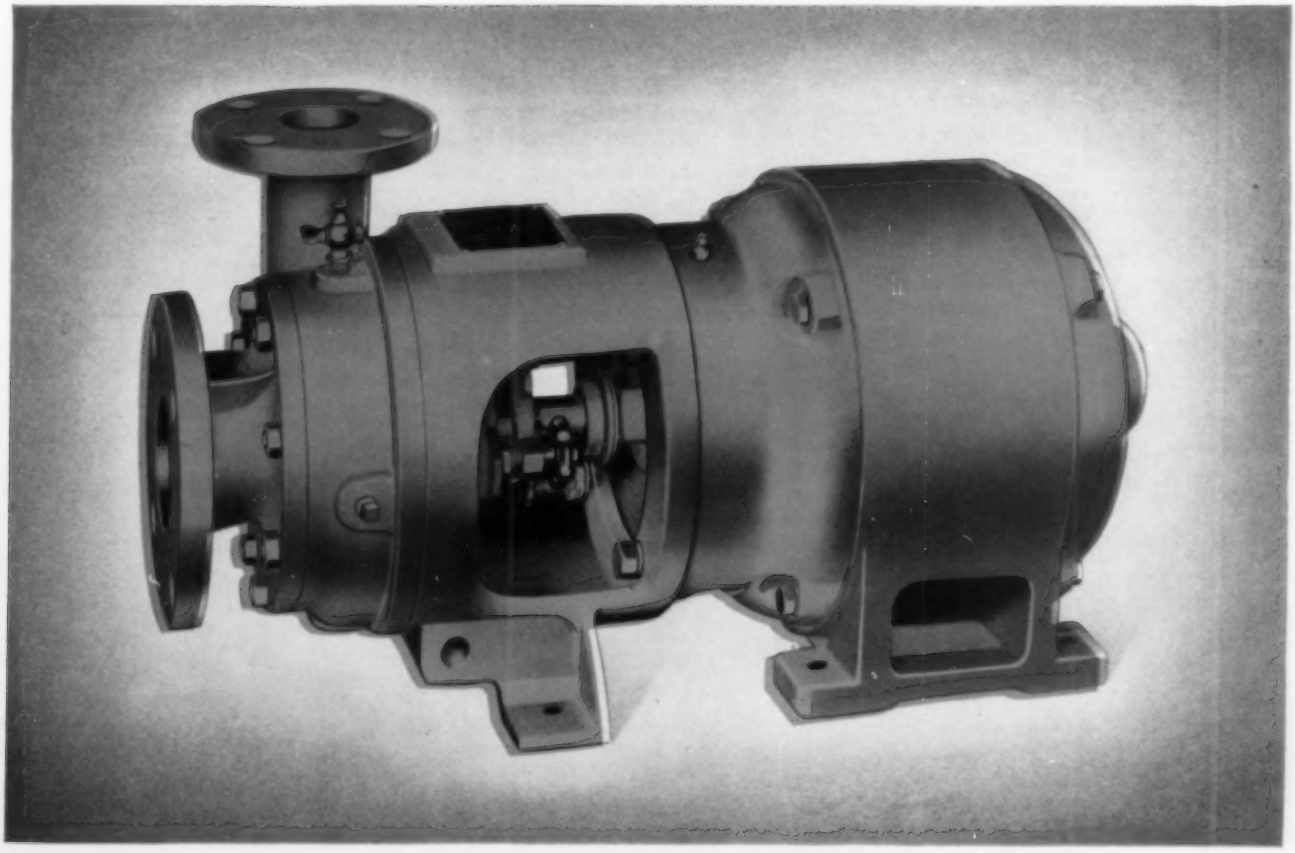

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THEY'RE KNOWN AS NORTON MOUNTED WHEELS *and* POINTS

BURRING is an important finishing operation on thousands of aircraft parts—both in the airframe plants and the motor plants. And many of these burring operations are being done with Norton Mounted Points and Mounted Wheels.

They are available in nearly 200 standard sizes and shapes. Made of Alundum or Crystolon abrasive, with vitrified, resinoid or rubber bond, they are securely cemented on rust-resistant steel spindles. Complete catalog on request.

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NORTON ABRASIVES

ON THE COVER

OUR cover picture shows a DA-35 drifter drill at work on the 3200-foot level of a North American metal mine. The quartz-studded face gives ample evidence of the hardness of the ground. As is usual in highly resistant rock, the central cut consists of a group of closely spaced holes that will be shot out first to create a space toward which surrounding holes can break. A cut of this type is generally called a "burn" cut, but is also known in some mining districts as a "burn out," "Michigan," "Cornish," or "Shatter" cut. It consists of from three to five holes, all parallel, and is designed to shatter or pulverize a small section of rock that can be scraped out if it is not all expelled by the blast. One or more holes are not loaded with powder but are left open to provide a space into which the others can break.

•

IN THIS ISSUE

THE speed with which our badly crippled Pacific Fleet was restored to virtually full strength following the Japanese attack at Pearl Harbor is a fitting testimonial to the technical skill of the Navy and furnishes proof that Americans can rise from the floor following a knockdown and fight back savagely. *Our Comeback at Pearl Harbor* makes inspirational reading.

Although little known to the average person, fluorspar is a mineral without which, as our second article points out, it would be difficult to wage war. Each ton of open-hearth steel made consumes 6 pounds of "spar," and seven pounds of it is required to produce 100 pounds of aluminum.

Plastic-bonded plywood has given us a new construction material of great strength. It has important wartime uses that are discussed in our third article.

How power-driven industrial brushes accelerate war production is pointed out in a 2-page article.

PAUL HOFFMAN

WITH deep regret we record the death, on September 11, of Paul Hoffman, author of *Supercharging Aircraft Engines* in our current May and September issues and of *Sidelights on Our Weights and Measures* published in February, 1940. Born in Alsace-Lorraine and educated in Switzerland, Mr. Hoffman joined the engineering staff of Ingersoll-Rand Company in 1911 and became a specialist in turboblowers. In 1932 he was made chief engineer of the company's Phillipsburg, N. J., factory and served as such until 1940, when a heart attack enforced an absence of several months. Upon his return to duty he became the factory's consulting engineer, in which capacity he made important contributions to engineering developments relating to the company's expanded wartime program. His death came suddenly, following a second heart attack. Only two days before he died Mr. Hoffman called our attention to a typographical error in his September article. The word "enthropy" in line 9, first paragraph, second column, page 7138, should be "enthalpy."

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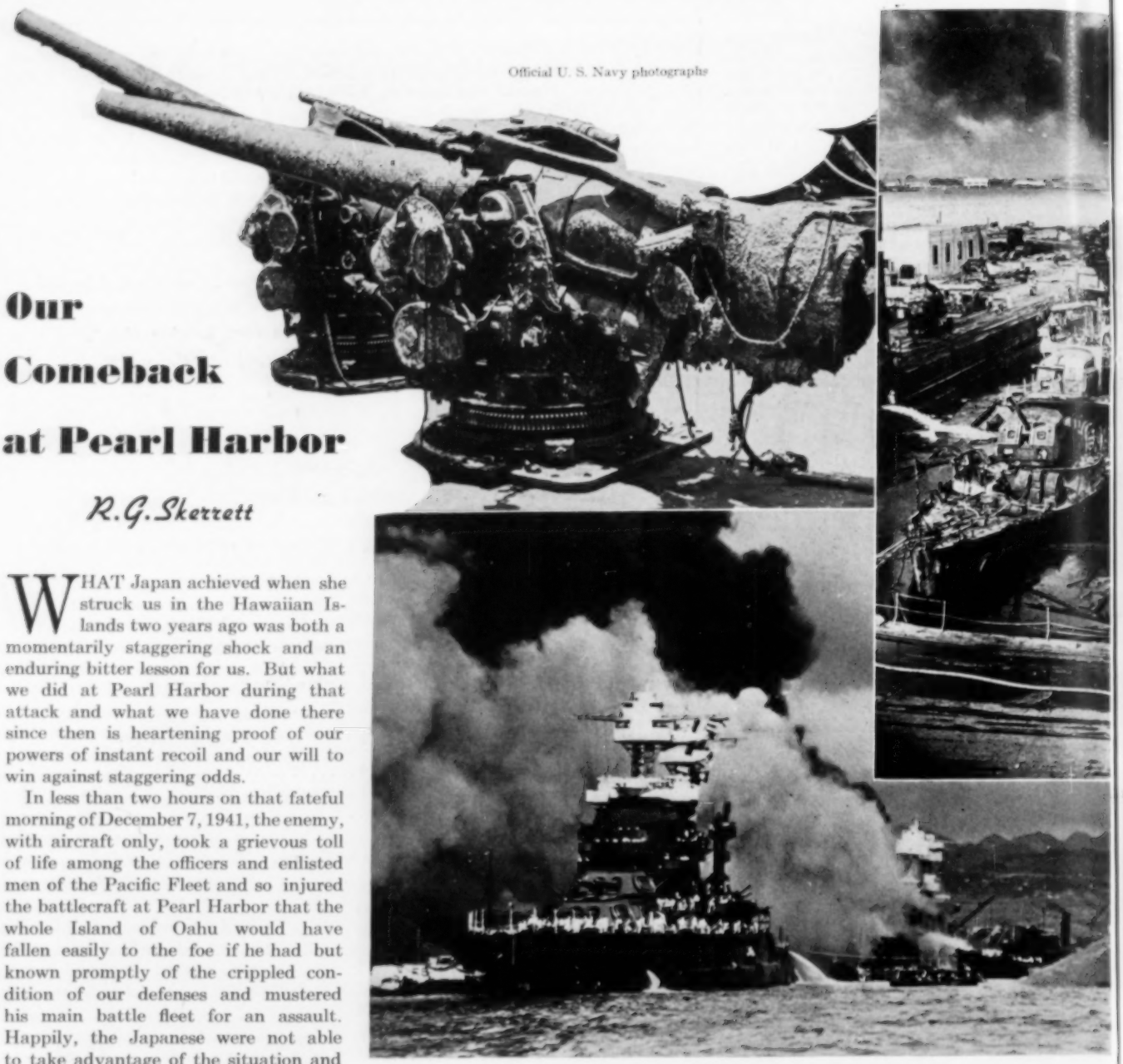
Our Comeback at Pearl Harbor

R. G. Skerrett

Official U. S. Navy photographs



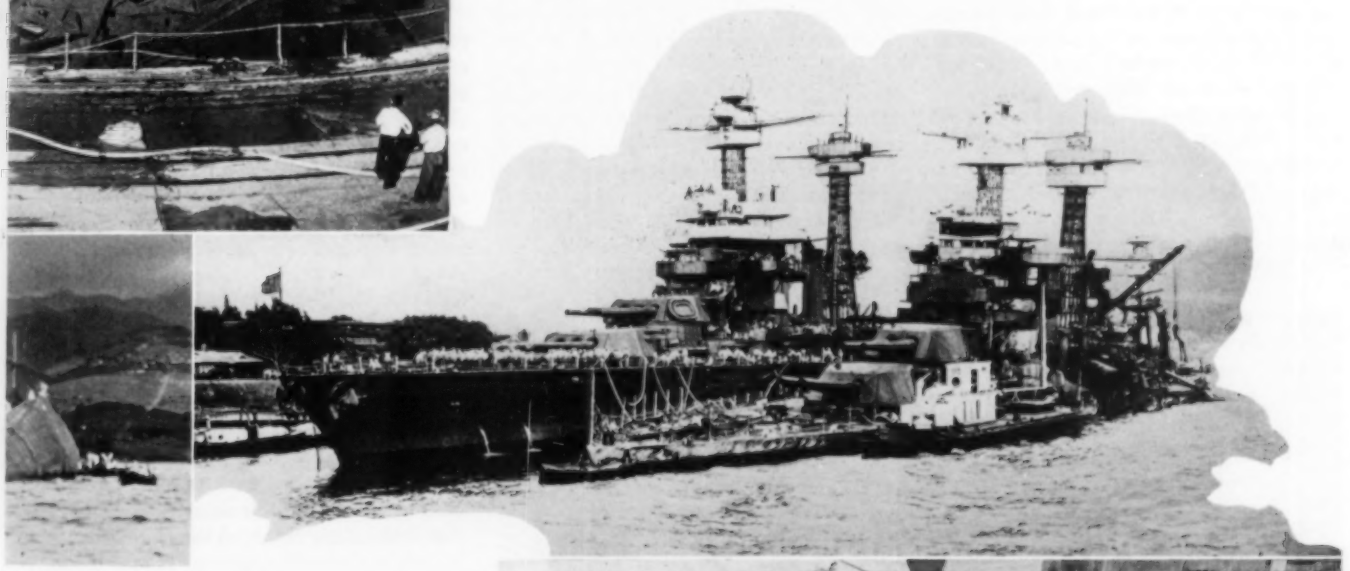
EVIDENCES OF DAMAGE

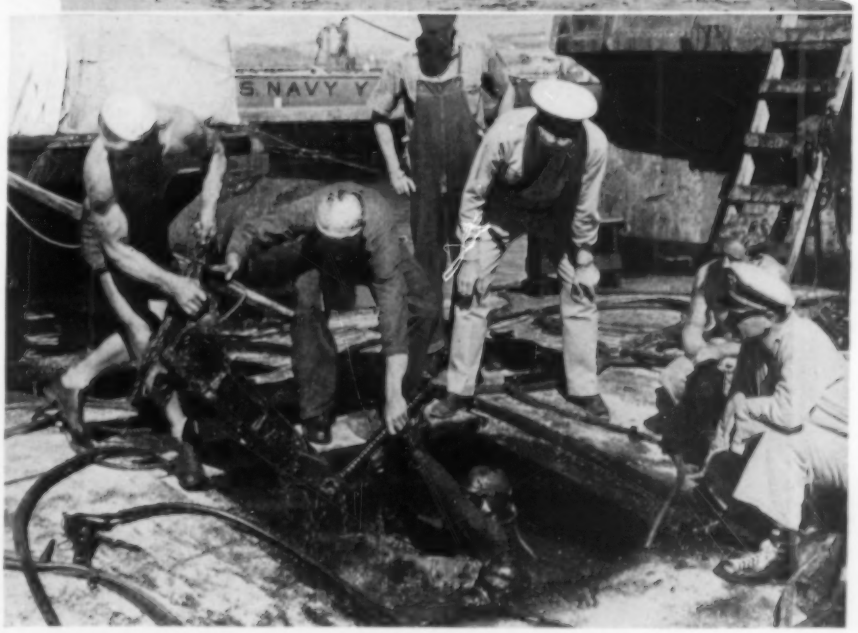
The picture just above was taken almost immediately after the attacking Japanese planes had left and shows billows of smoke rising from vessels that were still burning. The upturned hull of the capsized battleship "Oklahoma" appears at the right, and the U.S.S. "Maryland," which was inboard of the "Oklahoma" and consequently protected from aerial torpedoes, is on the left. She was little damaged and was one of the first of the stricken ships to rejoin the fleet. At the top-center is seen one of the great dry docks with a mass of jumbled wreckage. In the foreground are the destroyers "Downes" and "Cassin," which were bombed beyond repair but from which considerable machinery and fittings were salvaged. In the background is the battleship "Pennsylvania," 33,100-ton flagship of the Pacific Fleet, which was injured only slightly. The view at the right-center shows the badly damaged U.S.S. "West Virginia." The apparently uninjured craft alongside is probably the battleship "Tennessee." At the top-left are two barnacle-coated guns from the hopelessly blasted battleship "Arizona" as they appeared after long submergence. Much of the equipment of the "Arizona" has been reclaimed from the depths by divers of whom one is pictured at the bottom-right handing up part of a machine. A pneumatic chipping hammer, typical of the many air-operated tools used in the salvage and repair work, lies on the deck in the left foreground.

WHAT Japan achieved when she struck us in the Hawaiian Islands two years ago was both a momentarily staggering shock and an enduring bitter lesson for us. But what we did at Pearl Harbor during that attack and what we have done there since then is heartening proof of our powers of instant recoil and our will to win against staggering odds.

In less than two hours on that fateful morning of December 7, 1941, the enemy, with aircraft only, took a grievous toll of life among the officers and enlisted men of the Pacific Fleet and so injured the battlecraft at Pearl Harbor that the whole Island of Oahu would have fallen easily to the foe if he had but known promptly of the crippled condition of our defenses and mustered his main battle fleet for an assault. Happily, the Japanese were not able to take advantage of the situation and it was possible for us, through dint of resourcefulness, tireless energy, and the skillful use of all the facilities remaining available, to repair the still floating ships quickly and to salvage the sunken ones, for the most part, within an astonishingly short period.

Two years ago, Pearl Harbor was scarcely more than just a name for most of us. Still fewer of our citizenry that had provided funds totaling quite $100,000,000 for creating a commodious haven and repair base for our Pacific fleet were aware of how we acquired the right to make Pearl Harbor what it has become in a military sense. Tucked away in volumes detailing the voyage of the United States Exploring Expedition of 100 years ago is the pertinent account of how Lieut. Charles Wilkes, U.S. Navy, in command of a squadron assigned him, reached Honolulu in 1840 and how, while there, he was requested by the then king of the Hawaiian Islands to survey the great land-locked lagoon situated about 8 miles west of Honolulu and named Pearl River Harbor because it was the only known area about the islands in which the pearl oyster could be found. Lieutenant Wilkes had Pearl Harbor surveyed, and report-





tiations with the United States for a treaty of commercial reciprocity, which was ratified in 1875 and became operative the following September. That treaty was to remain in force for seven years and, unless either country expressed a desire to terminate it, for twelve more months. The treaty was a boon to the islands because it offered a ready market for their sugar and stimulated the development of the industry. So much was the Kingdom of Hawaii the gainer that many members of Congress were opposed to its renewal unless the United States would obtain some advantage thereby. The reciprocity convention was concluded near the end of 1884, but not ratified until December 9, 1887. Under the terms of that agreement, the United States Government was granted the exclusive right to enter the harbor of Pearl River and to establish and maintain there a coaling and repair station for the use of her vessels. To that end the United States was empowered to improve the entrance to the harbor and to do all other things "needful to the purpose aforesaid."

Having obtained the right of control, we did nothing to improve Pearl Harbor until after the Hawaiian Islands were annexed to the United States on August 12, 1898. Three years afterwards Congress appropriated $150,000 with which to acquire land for a naval station at Pearl Harbor and for harbor and channel defenses. In 1908 the Secretary of the Navy made this significant statement in his report: "The Department regards the immediate development of a base at Pearl Harbor as a matter of the highest importance. Congress at its last session authorized the construction of a dry dock at the naval station at Pearl Harbor, Hawaii, the limit of cost being fixed at $2,000,000." A year later, he stated: "The naval base at Pearl Harbor, Hawaii, has been started under favorable appropriations and conditions, and it is hoped that the building up of this important station can be rapidly

ed: "The depth of water at its mouth was found to be only 15 feet; but after passing this coral bar, which is 400 feet wide, the depth of water becomes ample for large ships, and the basin is sufficiently extensive to accommodate any number of vessels. If the water upon the bar should be deepened, which I doubt not can be effected, it would afford the best and most capacious harbor in the Pacific." There the matter rested until after 1874, when King Kalakaua ascended the Hawaiian throne and visited the United States.

A retired officer of the Medical Corps of the U.S. Navy not long ago described King Kalakaua as "a merry monarch, addicted to personal pleasures, and given to visions of aggrandizement." Whatever may have been his frailties, he had an eye to the financial betterment of his realm. He revived nego-

and economically carried on. Its importance and strategic value can hardly be overestimated."

Pearl Harbor is about 2100 nautical miles from San Francisco, and is the advance sea base for the defense of our entire Pacific Coast and the approaches to the Panama Canal. There, too, are stored, in immense quantities, ammunition, fuel, and other expendable supplies for our naval forces operating from that station. It has an expanse east and west of approximately 5 miles and of a little less than that north and south. Before much dredging was done the harbor had some 10 square miles of deep water and presented 30 miles of deep waterfront offering protection under all weather conditions. Many millions of dollars have been spent there since then in deepening, straightening, and widening the channel so that the heaviest of our battlecraft, when full laden or drawing even more water because of flooded compartments, could reach the base for repairs.

Cutting a channel across the reef at the mouth of Pearl River and amplifying the passage to the station called for the blasting and dredging of millions of cubic yards of coral rock, while immense quantities of other materials had to be excavated to deepen the harbor fairways around Fords Island and along the mainland waterfront to the eastward. As it stands today, the base has dry docks capable of accommodating the largest of our fighting ships, as well as machine and other shops equipped for all repair and overhaul jobs that may be needed for the maintenance of our Pacific Fleet. These same facilities have been of the utmost service during the salvage and work of rehabilitation following the Japanese attack. For the satisfaction of the canny-minded, let it be said that the aggregate of all sums spent on Pearl Harbor throughout the years of its upbuilding exceed by little the cost of one of the latest and largest of our battleships.

To have a clear picture of what has been done there since the raid, it is necessary to know what the hostile planes did to our major fighting vessels, most of which were moored in a double line close to Fords Island. The latter is centrally located in the East Loch of the great inlet and is the dominant air station of the naval base. It is supplemented by other airfields, both naval and military, only a few miles distant. To the south and west is the Marine Corps airport at Ewa; the Army has two, Hickam Field to the south and Wheeler Field lying northwest in the hinterland valley; and the Navy has another at Kaneohe Bay about 14 miles from Pearl Harbor and on the east coast of Oahu.

At the time the Japanese struck, there were in flying condition on the island 202 Navy and 273 Army aircraft of various types. Shortly before 7.55 a.m. enemy dive bombers swept upon the air station at Kaneohe Bay, inflicting much damage. Then they flew over the mountains to swarm above Hickam Field and the naval airport on Fords Island, attacking destructively and speeding thence to Ewa and to Wheeler Field. The foe's purpose was to destroy hangars, runways, and planes so as to immobilize our flying forces.

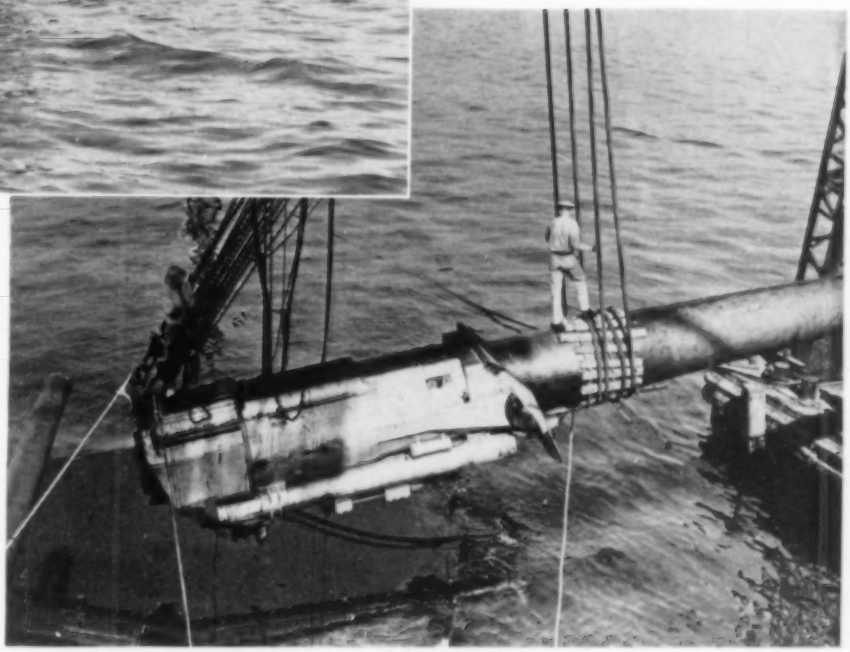
A few seconds after the appearance of the first dive bombers others "swung in from various sectors," together with torpedoplanes, and concentrated their attack on the heavy ships in Pearl Harbor. Taken by surprise, the vessels had to engage the foe with their ready machine guns, but quickly supplemented heavier antiaircraft batteries for those light weapons as the crews were called to general quarters. In the absence of effective coöperation aloft, those batteries constituted the prime defense of the Pacific Fleet against continuous aerial bombardment, and it is said that nearly all of them were in action within five minutes of the sounding of the alarm.

According to the Navy Department's official statement: "Torpedoplanes, assisted effectively by dive bombers, constituted the major threat of the first phase of the Japanese attack, lasting approximately half an hour. Twenty-one torpedoplanes made four attacks, and thirty dive bombers came in in eight waves during this period. Fifteen horizontal bombers also participated in this phase of the raid." Then followed a let-up in the enemy's operations during which horizontal and dive bombers made intermittent attacks, the latter intensifying their destructiveness by crossing and recrossing their targets from various directions. In the meantime reappeared what were probably the same dive bombers that had taken part in earlier stages of the operations; and this concluding phase of the raid, which lasted for about 30 minutes, was devoted in the main to strafing—killing and striking at every opportunity. At 9.45 a.m. the last of the foe swung seaward and disappeared.

Such of the Army and Navy aircraft as were not too crippled to get off the ground from runways that had not been entirely disrupted participated in the defense of Pearl Harbor and scored against the enemy air force, which is believed to have been composed of 105 planes—21 torpedoplanes, 48 dive bombers, and 36 horizontal bombers. The Japanese lost 28 of them due to Navy action, and Army fliers shot down more than twenty. Furthermore, the Navy sent three small hostile submarines to the sea bottom. Eighteen Navy scout bombers from a United States airplane carrier that was nearing Pearl Harbor while the attack was underway joined in the effort to repel the foe, and four of them were brought down. Later, all but

PEARL HARBOR AREA

Section of a U.S. Geological Survey map. The naval station occupies most of the eastern (right) half of the harbor, where the naturally deep water of the landlocked basin has been dredged to a depth of 45 feet. The main naval air base is on Fords Island, alongside which many of our battlecraft were moored when the Jap assault came. The Navy yard proper is on the eastern shore of the East Loch. The Marine Corps air field is at Ewa (lower-left), and the Army's main air base is Hickam Field below Fords Island.



SALVAGING THE "CALIFORNIA"

The bow of the battleship "California" breaking water after the pumps had partially unwatered her. A section of the cofferdam that was built to aid in floating the vessel can be seen along her right side. The lower picture shows one of the big guns being removed from the ship. It obviously had not been underwater.

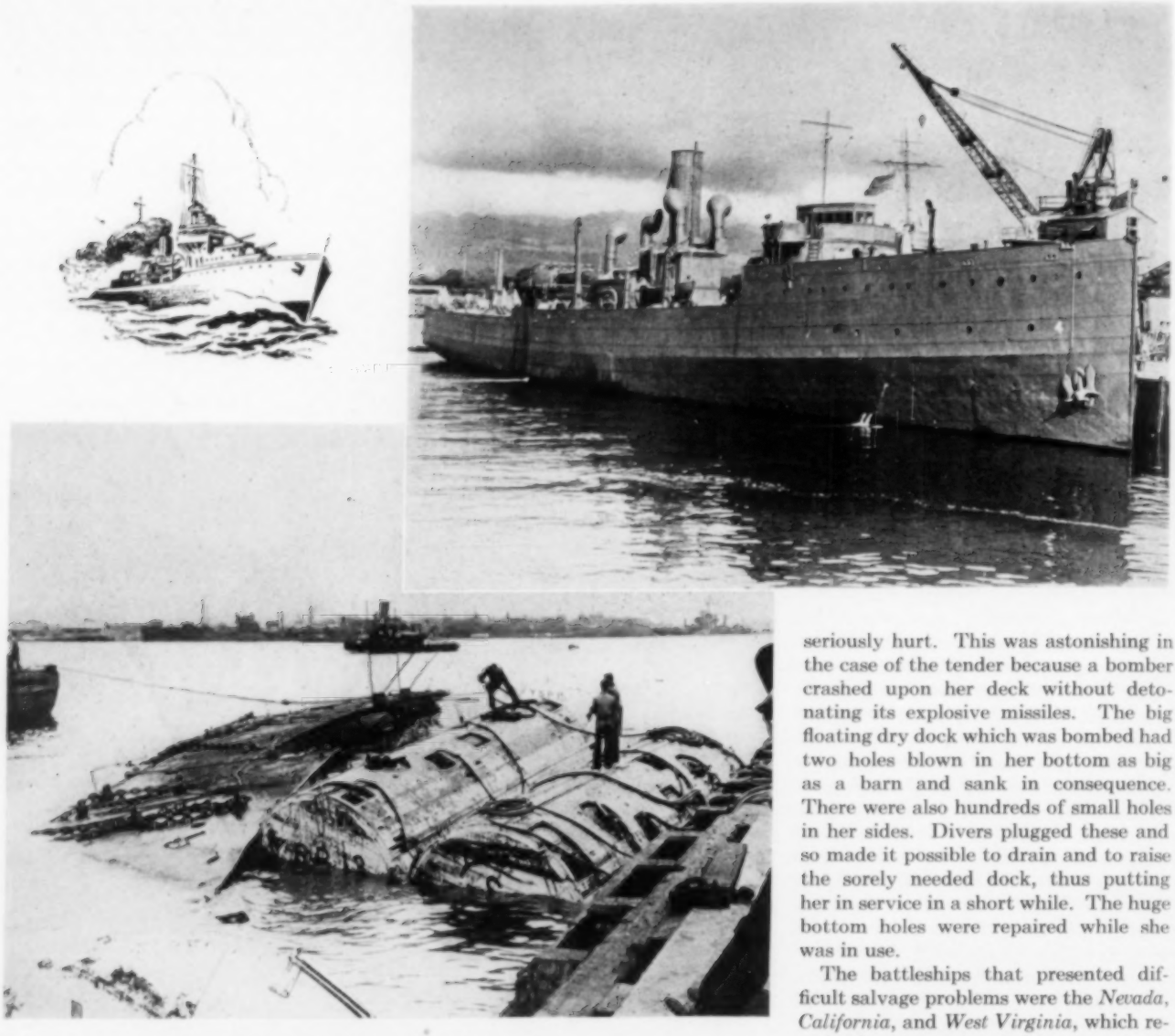
one of the remaining fourteen took off again in an unsuccessful search for the carriers from which the raiders reached Pearl Harbor.

Not counting small vessels, there were moored at the naval base when day dawned December 7 a total of 86 ships of the Pacific Fleet. Among that aggregation were eight battleships, seven cruisers, 28 destroyers, and five submarines. When the raid ended, it was found that there had been sunk, or so severely battered that none would serve a military purpose for some time to come, five battleships—the *Arizona*, *Oklahoma*, *California*, *Nevada*, and *West Virginia*; two destroyers—the *Cassin* and *Downes*; the minelayer *Oglala*; and the target ship *Utah*, an overage battleship. In addition, three battleships—the *Pennsylvania*, *Maryland*, and *Tennessee;* three cruisers—the *Honolulu*, *Raleigh*, and *Helena*, the latter lost recently in a fight that cost the Japanese dearly; the seaplane tender *Curtiss*; the repair ship *Vestal*; the destroyer *Shaw*; and a large floating dry dock were damaged in varying degrees. Of the nineteen vessels that suffered because of the raid, most of the first-mentioned have long since been salvaged and restored to active service, while the latter group was repaired and made ready to operate within three weeks to six months, depending upon the gravity of their injuries.

The most distressing feature of the Japanese attack was the toll in life and injury among our men. Of the Navy and Marine Corps, 2117 officers and enlisted men were killed, 960 missing, and 876 wounded, most of whom were saved. The Army's casualties consisted of 226 officers and enlisted men, who were killed or succumbed to their injuries, and 396 wounded, who recovered and were able to return to duty.

Fortunately for us, the shop and repair facilities at Pearl Harbor were not incapacitated, and it is said that even before the last bomb fell the work of restoration had been started. Contractors engaged there on large construction jobs, the regular working force of the naval station, combined with the efforts of the uninjured members of all the vessels, turned to with a will and labored "the clock round" day in and day out to clear away the wreckage. Added help in the form of specialists and essential equipment was speeded from the west coast by aircraft and fast ships. Only the most pressing of the repair and salvage jobs were given priority; the others were slowed up or halted time and again so that battleships put out of commission during far-flung engagements in the Pacific could be made fit for service at sea.

Of the nineteen vessels damaged at Pearl Harbor, only three have so far been stricken from the Navy's list and two remain to be salvaged. A chance bomb entering the *Arizona* by way of the smokestack detonated a magazine, breaking the 28-year-old battleship in half and sending her to the bottom a mass of shattered, twisted steel except for the after half, which was more or less intact. From that old battle wagon have been recovered guns, much machinery, and other useful material for use elsewhere. The destroyers *Cassin* and *Downes*, which were in dry dock at the time of the raid, were bombed, and blew up. Even so, about 50 per cent of their main and auxiliary machinery has been salvaged. Also in dry dock were the destroyer *Shaw* and the



REFLOATING OF THE "OGLALA"

In the lower view the mine ship "Oglala" is seen lying on her side, with pontoons in position to begin righting her. The other picture shows the vessel after having been righted and repaired.

battleship *Pennsylvania*. The former had her forebody blasted off but was later fitted with a temporary steel bow at Pearl Harbor and made her way under her own steam to a west coast shipyard for complete renovation. The *Pennsylvania*, which fought valiantly and successfully with her aircraft batteries, was hit by a bomb which did moderate damage to her bow. That injury was repaired in two weeks.

The attack of the Japanese torpedoplanes was extremely effective and would have been more so except for the fact that the battleships—their main targets—were moored in pairs, side by side, along the shore of Fords Island and the torpedoes, launched from the outlying open water of the harbor, could reach only the vessels exposed in that direction. It was because of this that the inner line of ships, except the *Arizona*, was damaged only by bombs, and therefore much less seriously. The *Tennessee* and *Maryland*, which were in the inner line, were bombed but only slightly damaged.

The battleships that have required the services of salvors and more or less extensive repairs have been the *Nevada*, *West Virginia*, *California*, *Oklahoma*, and *Utah*. These rested on the harbor bottom, three of them upright and two overturned. The cruiser *Raleigh* was both torpedoed and bombed, and would have capsized before grounding but for the skillful and strenuous work of all hands aboard. The 10,000-ton cruiser *Helena* was hit by an aerial torpedo but was not incapacitated. On the other hand, the *Oglala*, which was alongside the *Helena*, was so injured by the concussion of the same torpedo that she filled and sank, coming to rest on her port side. The seaplane tender *Curtiss* and the repair ship *Vestal*, although struck a number of times, were not seriously hurt. This was astonishing in the case of the tender because a bomber crashed upon her deck without detonating its explosive missiles. The big floating dry dock which was bombed had two holes blown in her bottom as big as a barn and sank in consequence. There were also hundreds of small holes in her sides. Divers plugged these and so made it possible to drain and to raise the sorely needed dock, thus putting her in service in a short while. The huge bottom holes were repaired while she was in use.

The battleships that presented difficult salvage problems were the *Nevada*, *California*, and *West Virginia*, which remained upright after sinking or grounding, and the *Oklahoma* and *Utah*, which capsized and had to be righted before steps could be taken to refloat them. The job of reclaiming the *Oglala* was a relatively easy one because that craft has an over-all length of about 386 feet and a displacement of but 4,200 tons. At Pearl Harbor the normal rise and fall of the tide does not exceed 2 feet and occurs twice a day. For this reason ordinary surface pontoons could not be used to lift the vessel or to help restore her to an even keel. Therefore submergible pontoons, that could be sunk to the harbor bottom, were attached to the *Oglala* by chain slings that were secured near the main deck on the upturned side and carried down and under her keel to the rail of the submerged side. When the pontoons were made buoyant by expelling their water ballast with compressed air, they developed a lift of considerable moment, causing the sunken ship to roll over in the desired direction and to become upright. Later, when all holes that might admit water had been sealed and a cofferdam forming

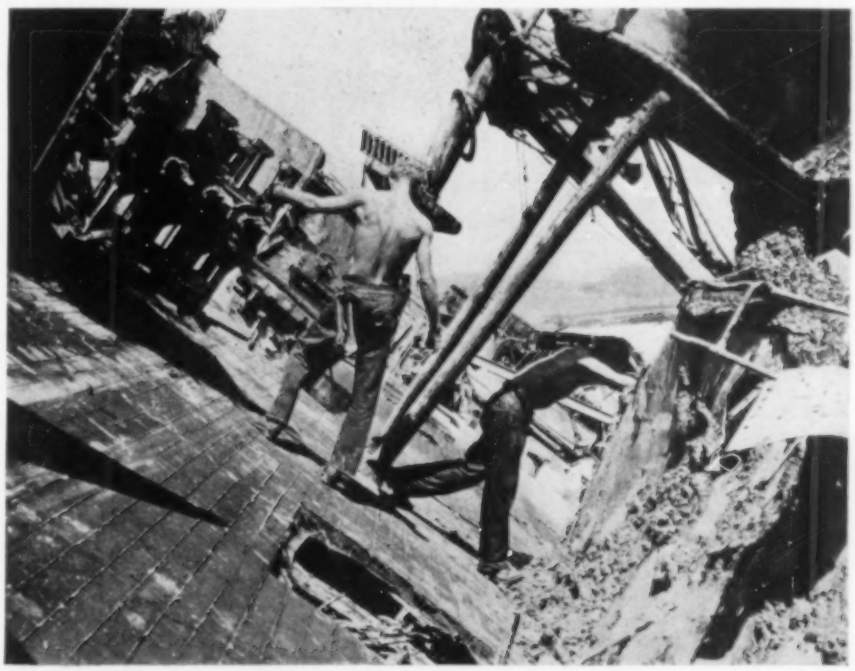
an extension of the vessel's side had been constructed to a point above the water line, then pumping was started to give the craft sufficient buoyancy to permit her to be towed into dry dock for permanent repair.

The battleship *Nevada*, beached in comparatively shallow water and resting upright, was the first of the big vessels to be tackled because she was manifestly the one that could be easiest refloated and moved for rehabilitation. The job was, nevertheless, a big one and manysided. The *Nevada* has an over-all length of 583 feet and a displacement of 29,000 tons and had been badly damaged by the concentrated attack to which she was subjected while seeking to make a break for the open sea. The salvage operations consisted of first taking from her everything that could be readily removed to lighten her. Next, all openings in her hull were closed with patches or by other means preparatory to unwatering all submerged parts of her body. Wrecking pumps of various types aboard the ship were then set in motion to withdraw enough of the water to give her sufficient buoyancy to float clear of the beach on which she had been run to save her. Once afloat, she was towed to a dry dock and carefully landed on the keel blocks for cleaning and complete overhauling. Simple as this may sound, the preparations for the refloating of the *Nevada* and the operations that followed were both complex and varied and required qualified workers in many fields whose activities were preceded by resourceful and exact planning.

The *California*, five years younger than the *Nevada*, has an over-all length of 624 feet and a displacement of 32,600 tons. This is an immense and ponderous body to control when damaged and resting on the muddy bottom even of a sheltered harbor. The battleship's forebody lay underwater, and although her watertight bulkheads had been sealed at the sounding of general quarters, the submerged compartments could not be drained to give the vessel buoyancy until the forebody was, in effect, brought up above the surface. This was done by means of a timber cofferdam that was through-bolted to the hull plating and carried up well above the surface of the water. It was strongly braced transversely to resist external hydrostatic pressure as the impounded area was pumped out. Trained divers, equipped with air-operated tools designed for service underwater, got the cofferdam in place and anchored it—working both outside and inside the vessel. In much the same fashion all holes or damaged areas of the submerged part of the hull were closed with either steel plates or wooden patches secured to the skin by bolts. With these preliminaries completed, the cofferdam and the flooded hull compartments were unwatered. Once afloat and sufficiently lightened to move her slowly, the *California* was towed into dry dock to undergo cleaning and repair—a force of many hundreds being engaged on her at one time. The job of overhauling was necessarily protracted because of the

THE "OKLAHOMA"

The "Oklahoma" was badly hit and her salvage was a tremendous task, entailing a vast amount of work by divers. That they might thread their way through the maze of subdivisions in her capsized position, a scale model was made to show them the location of passageways. On the barge alongside the vessel (bottom) are two Ingersoll-Rand K-500 portables that supplied them with compressed air. Smashed sections of the main deck, still aslant and covered with mud and barnacles after seventeen months of immersion, are seen in the upper picture.



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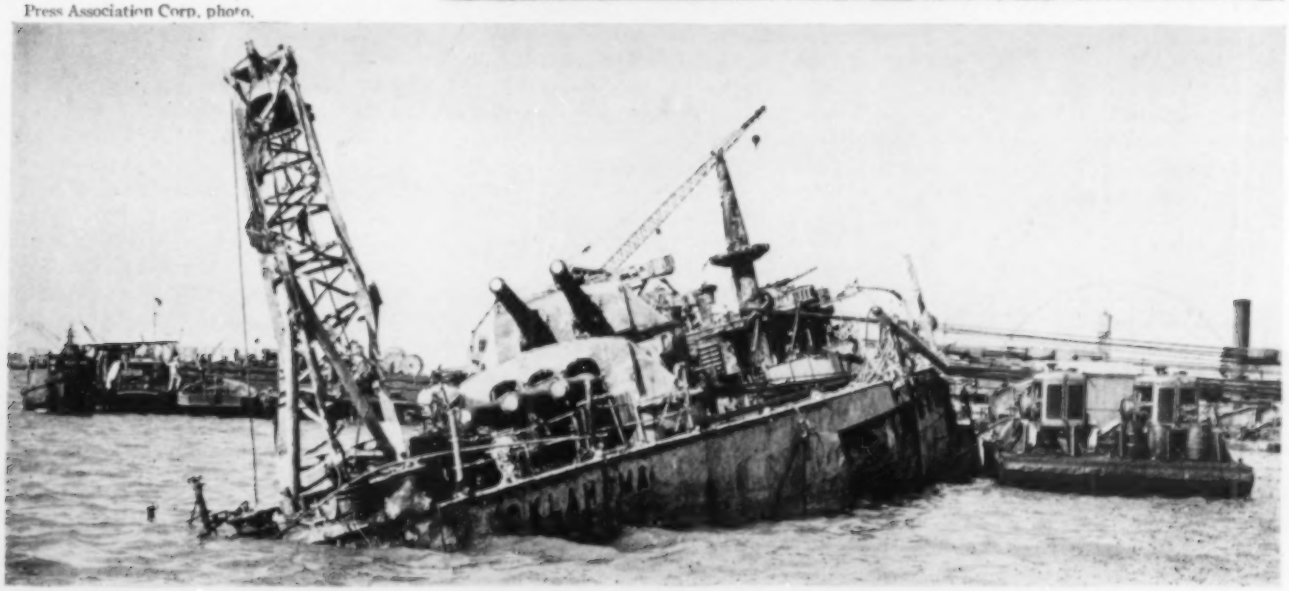
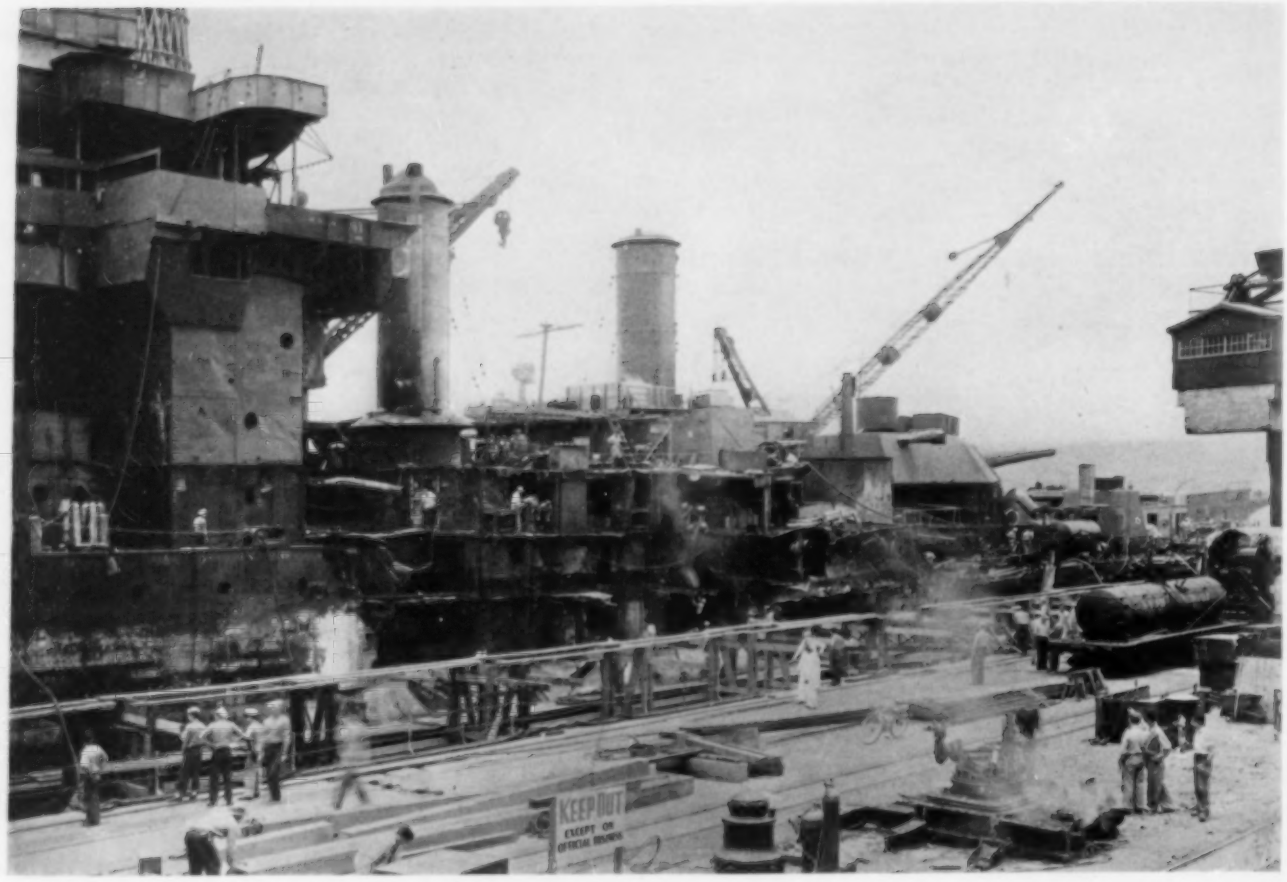




WHERE JAP BOMBS STRUCK

A close view of the battleship "West Virginia" in dry dock, with her near side still displaying ample evidence of the damage that caused her to sink. Her rehabilitation, long since completed, was a major job.

damage done during submergence to her propelling units—large and powerful electric motors.

The *West Virginia*, a sister ship of the *California*, also had great holes in her side from bombs and torpedoes and rested upright on the harbor bottom. In refloating here, the salvors substantially followed the procedure employed in unwatering the *California*, the main departure being the cutting away by divers of the badly shattered and twisted steelwork inside her. Air-driven tools and several types of burning torches were utilized in doing this laborious and dangerous work in advance of temporarily patching the hull and attaching the cofferdam sections. The air needed during the refloating and dry-dock operations was supplied by both stationary and portable compressors.

The *Oklahoma*, when the last official report was issued, was partly righted, and the capsized *Utah* remained to be salvaged. A description of what is being done to get the *Oklahoma* back on an even keel will also apply to the *Utah*, as the methods of refloating will probably vary little. It might be mentioned here that the success achieved at Pearl Harbor is the result of years of experience in commercial ship salvage and harbor-construction work—experience that the present struggle is serving to broaden considerably—and of mechanical developments that have come to the aid of our Pacific naval base in the course of the last two decades.

The *Oklahoma*, a sister ship of the *Nevada*, was first commissioned in May, 1916, and was officially overage a year ago. Notwithstanding that classification she is armed with formidable main and secondary batteries and well equipped with antiaircraft guns. True, her propelling machinery consists of triple-expansion engines, but this will permit putting her back into first-class shape more quickly than would be possible if she had electric drive. This should be remembered when trying to evaluate the outlays involved in restoring her to active service. When she was built, her hull and machinery alone cost about $6,000,000, and many more millions were spent for armor and armament, aside from other fittings and equipment.

During the Japanese raid, the *Oklahoma* was hit time and again by torpedoes and bombs, which opened her up. Many of her compartments were flooded and, finally, she heeled over and capsized as she settled in deep water. Indeed, her plunge took place within seven or eight minutes after she had been hit, and it was because of this abruptness that she carried down with her more than 400 of her complement of around 1730 men. The ship came to rest on her port side with a list of 150° from the vertical.

A naval vessel is a veritable honeycomb of steel subdivisions, and there is no waste space. The people aboard have to learn the intricacies of the passageways on each deck and the means of ingress and egress from deck to deck. Imagine the puzzlement of divers entering such a hull when sunken, turned nearly halfway upside down, cluttered with shifted equipment, and at intervals a tangle of shattered and twisted steel. In addition to these conditions, the salvors of the *Oklahoma* were confronted with an inert body of 29,000 tons, partly embedded in the mud of the harbor bottom, flooded, and also heavily loaded with mud forced into her by her own weight and momentum as she sank. Further, the ship's damaged mast and superstructure tended to anchor her more firmly to the water bed.

Before any effort could be made to right the craft, divers had to get into her so as to examine her and furnish information on which to plan the

work. At that stage they had to contend with floating oil, as well as water and mud; and so that they could reach their objectives, some of these accumulations had to be removed. This was done by cutting holes in the upturned, undamaged side of the vessel with oxy-acetylene torches and by fitting over each of them an air lock such as is used in caisson sinking in constructin foundations for big buildings in water-bearing ground, for example. The air locks made it possible to apply pneumatic pressure to flooded compartments and gradually to force the oil, water, and mud out through wounds or other openings. Even while this was going on divers could enter and leave these subdivisions to explore beneath the flood level, or other men used to working under pressure could tackle necessary jobs in partway-evacuated compartments. Furthermore, with the latter under air pressure, openings in them could be temporarily sealed with patches, thus giving a degree of buoyancy that would aid in lightening the dead weight that would have to be overcome in forcibly pulling the ship back to a vertical position.

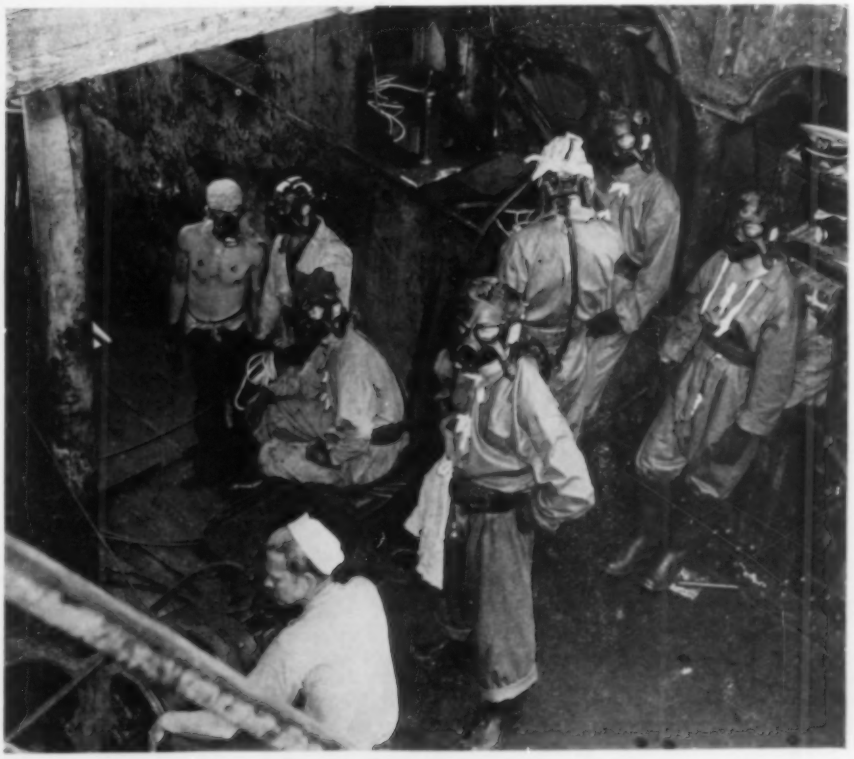
A scale model of the *Oklahoma*, fashioned of composition board by a petty officer of the Navy, served to train the divers so they would know how to move in going to and from any subdivision. It was a reproduction of the internal get-up of the craft and could be taken apart in sections for inspection. With this mental picture, and depending entirely upon his sense of direction and touch, a diver could perform his task in complete darkness. For underwater work, the men wear the regulation naval diving dress; but for operations in partly flooded spaces, and in the presence of obnoxious gases, they don an ingenious, simple rubber headdress with an air-line connection that enables them to make brief submergences in slanting compartments where the water may at times be slightly above their heads.

In doing the salvage work, both underwater and above, such air-operated tools as impact wrenches, reversible and non-reversible drills, chipping hammers, and Utility hoists have speeded the many tasks involved. Where air from stationary compressors has not been available or ample for the numerous demands, portable units have been used to provide air for both divers and pneumatic equipment. Some of these portables were of the large K-500 Type having a capacity of 500 cfm. at 100 pounds pressure. These machines are designed to that they can supply air at a lower pressure suitable for diving work.

With the *Oklahoma* freed of some of the removable dead weight, and with many of her holes closed with patches, the next step was to right her and, at the same time, to break the seal or hydrostatic grip of the mud in which the wreck had partly settled. This strenuous job was awarded to the Pacific Bridge Company of San Francisco, Calif To the upper works of the superstructure and to the submerged side of the main deck, the contractor proceeded to secure steel cables that pass up and across the main deck, over the starboard or uppermost rail, and then shoreward to a battery of powerful winches arranged in line along the waterfront of Fords Island. The tug of the cables, nicely controlled, was applied intermittently, and in six weeks the ship was gradually rolled over and into an approximately vertical position.

The work that has gone forward since her partial righting has been a tremendous and at times a gruesome job of house cleaning. Care has had to be taken to forcibly ventilate the interior of the vessel during salvaging to get rid of insidious and deadly hydrogen-sulfide gas. This was done with the aid of air under pressure and with blowers.

It is not possible to give credit by name to all the officers and enlisted men of the Navy or to the contractors' personnel and others engaged in rehabilitating the greatest of our naval bases in the widespread Pacific; but each and all have given of their unstinted best and made possible the amazing record of our comeback at Pearl Harbor.



NAVY DIVERS

The gear worn by the divers differs according to the depth of water in which they work. At the right are several of them equipped with soft rubber masks with air-hose connections and wearing weighted belts to neutralize the natural buoyancy of their bodies. They are standing by to descend into the magazines of the shattered battleship "Arizona" to remove the remaining powder, much of which is being reconditioned for further use. At the lower left is an air-operated hoist that is serving to bring the powder up The picture above shows a diver after working in a section of the "Arizona" in which oil had escaped.

Fluorspar Helps Wage War

Roscoe Fleming

Photos by Thos. J. Barbre

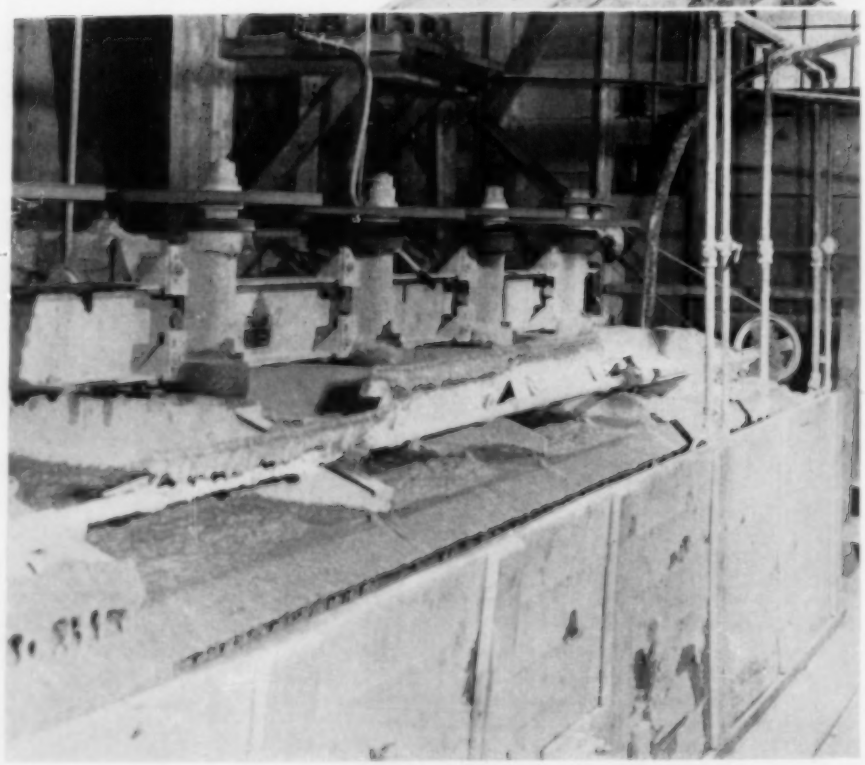
FLUORSPAR is a mineral without which our war effort would be much less effective and the end of hostilities would be much farther off. It is calcium fluoride, source of fluorine, fiercest of the elements. It is found in virtually every color of the rainbow and, characteristically, in crystalline form. In some parts of the country, particularly in the West, it exists as a varicolored, soft, heavy rock that feels slightly soapy and "alive" to the touch; but in the Arkansas River Valley of Colorado it occurs in thin flat layers that differ in color—the "bacon type," said to be found nowhere else.

For four major purposes, both in times of war and peace, fluorspar is well-nigh indispensable to American industry, as follows:

First, it is used in large quantities—242,000 tons in 1942, probably 300,000 tons this year—as a flux and scavenger in steelmaking.

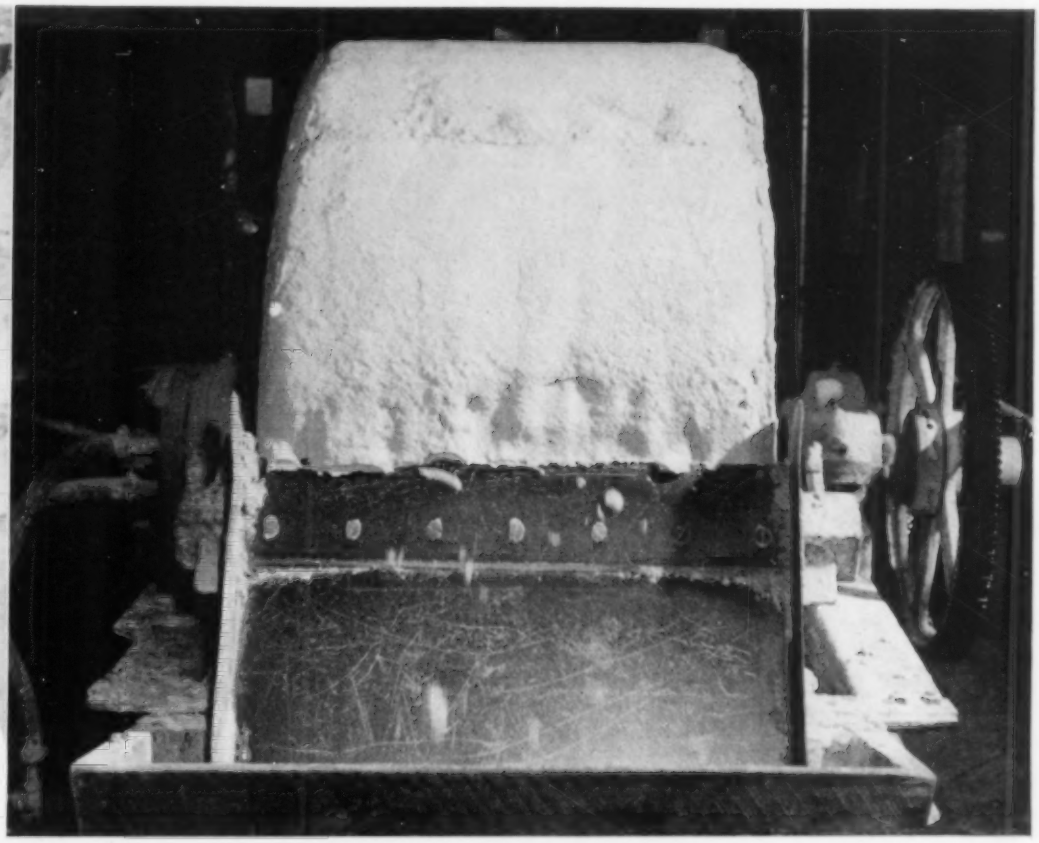
Second, hydrofluoric acid derived from it is required in the production of artificial cryolite which, in turn, enters into the manufacture of aluminum by the electrolytic process. Shipping is thus saved for more essential purposes, as the only available source of natural cryolite is Greenland. Moreover, the artificial product can be much more closely controlled. The importance of fluorspar in this field is appreciable, for we are informed that 1,500 pounds of it are needed in producing the aluminum for a heavy bomber.

Third, hydrofluoric acid has come to



THE KRAMER MILL

Ore from the two properties being mined is trucked to the mill (top, left) which can handle 200 tons daily. The principal source of ore is close to the mill, where the fluorspar veins are cut at relatively shallow levels by two adits. At the top, center, is shown a 1-ton car of ore being pushed out of one of these openings. The ore is treated by the flotation process. There are three 6-cell Denver "Sub-A" flotation machines, one of which is pictured above. Because of the difficulty of pumping the fluorspar flotation froth that is formed by adding oleic acid, gravity flow is provided wherever possible. Final dewatering of the concentrate is done by the rotary filter seen at the top, right. Suction draws moisture from the filter cake, which is scraped from the drum into a kiln for further drying.



be the ranking catalyst in making high-octane gasoline for aerial warfare. It is rapidly replacing sulphuric acid in this work because, unlike the latter, it can be used over and over again without expensive recovery and cleaning.

Fourth, hydrofluoric acid is needed in the manufacture of optical glass for range finders, binoculars, etc., which are essential in warfare. It has many other applications—in the ceramic industry, in making refrigerants and insecticides, and in etching glass, but these are more important in peacetime than at present.

All the war uses create an enormous demand for fluorspar. It is estimated that the total needs of the United States this year will approach 500,000 tons, as contrasted with a consumption of 218,000 tons in 1940. Output for 1943 was first estimated at less than 400,000 tons, and the remaining 100,000 tons were to be made up from stock piles (98,000 tons at the beginning of 1942) and imports. However, the indications are that the production estimate may be exceeded chiefly because of the rapidity with which new mines and mills are being developed in the West.

In the past, about 86 per cent of the nation's fluorspar was obtained from mines bordering the Ohio River in southern Illinois and western Kentucky. There is plenty of the mineral in the West, but ordinarily it is too far from the great consuming markets—the steel, aluminum, and glass mills of the East—to offer more than minimum competition there. But war requires more than Illinois and Kentucky can supply, and western deposits, chiefly in Colorado and New Mexico, are expected to provide more than 100,000 tons this year, or 25 per cent of the national total.

One of the most interesting operations is the new and extremely modern mill of Kramer Mines, Inc., situated 10 miles from Salida, Colo., in the upper Arkansas River Valley above the Royal Gorge and at an altitude of 7,600 feet. Substantial tonnages of fluorspar have been obtained there for years by three other companies, all of which are now in heavy war production. In the case of Kramer Mines, Inc., ore is coming from two developments. One is at the mill, where both surface and underground mining are being carried on. The other is 18 miles away and 9,600 feet above sea level on the tree-studded side of Poncha Pass that leads into the great San Luis Valley of Colorado from the Arkansas River watershed. In the words of R. W. Kramer, president of the company, that deposit "may provide only a few thousand tons of much-needed ore, but, on the other hand, may prove to be a tremendous source of fluorspar."

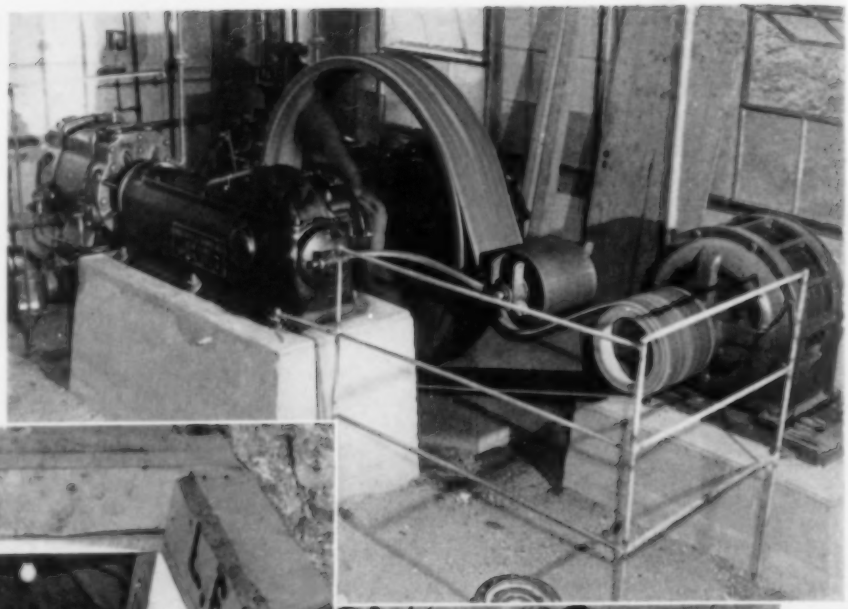
At Poncha Pass, the mineral exists, at least on the surface and as far down as exploration has proceeded, in no discernible pattern. It is simply there, in pockets and lumps and ledges, and is at present being mined by open-pit methods. About 70 tons are being taken out daily, and the best of the material can be crushed and shipped without further treatment as metallurgical fluorspar. The prospector who located the deposit and many others, F. A. Mansheim of Salida, says that test holes show mineral throughout a distance of 1,800 feet, and the American Fluorspar Company, working 1½ miles away across the same mountain, is said to be finding much the same sort of ore.

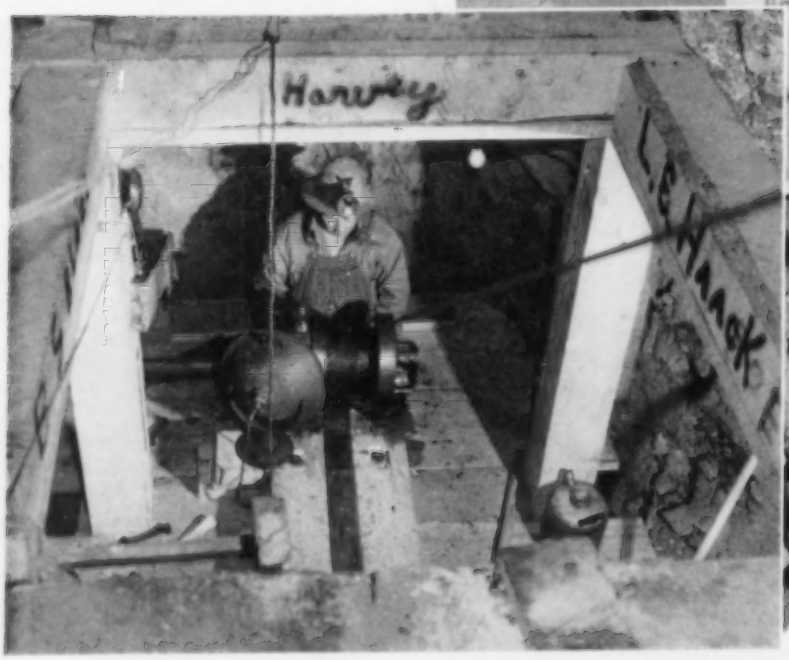
The veins being worked at the Kramer mill are in pre-Cambrian rocks. The portal of the mine is at mill level. About 4,500 feet of drifts, approximately 6x7 feet in cross section, have been driven, with the main drift having a slightly upward trend. Progress in drifting is unusually rapid. The drills in use are Ingersoll-Rand JB-5 Jackhamers mounted in shells, with a sliding cone that permits the employment of 5-foot starter steel. Only one change is made, to 7-foot steel, and the hole is finished a few inches short of 7 feet. Detachable bits of the Jackbit type are utilized exclusively—the starters being of 2-inch gauge and the finishing bits of 1⅞-inch gauge. Air at more than 75 pounds pressure is delivered at the working face and is furnished by an Imperial Type 10 compressor. Stoping is soon to be undertaken, and will be of the shrinkage type.

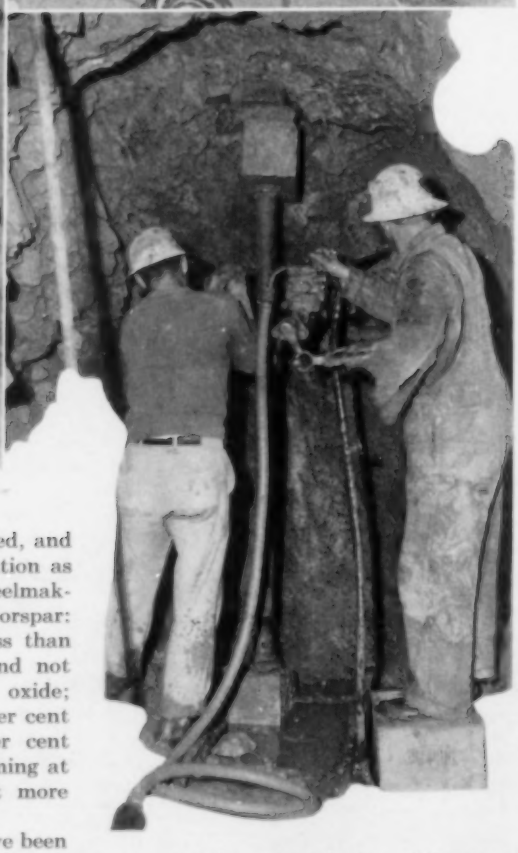
It takes only three to four minutes to put down a hole, exclusive of changes, and from seven to eight holes are drilled

COMPRESSED-AIR EQUIPMENT

An inclined winze, 127 feet deep, has been sunk to open up mineral below the haulage level. A skip of ½-ton capacity powered by the air-operated Little Tugger hoist shown below is used to transport ore and materials in the winze. Underground drilling is done with shell-mounted Ingersoll-Rand JB-5 Jackhamers, as pictured at the lower right. Compressed air for these and other purposes is supplied by an Ingersoll-Rand belt-driven compressor (right).







to a round, the pattern being varied to pull the greatest amount of material consistent with ground conditions. The formation is predominantly soft and the workings are relatively dry. Holes are loaded with 60 pounds of 40 per cent DuPont special gelatin, which breaks up from 270 to 290 cubic feet of rock. The explosive is fuse-fired. With the recent completion of a raise to the surface, smoke and gases dissipate rapidly, and work can be resumed in fifteen minutes after a blast. Drilling is done by contract by 3-man crews, and the total time required to drill, shoot, and muck is about seven hours. Lately, a 127-foot winze was sunk, and drifting is now in progress at the bottom of it. Ore is being taken out through a station built there, a Tugger hoist serving to lift and lower a bucket of 1,000 pounds capacity that handles all ore, waste, and supplies. One-fourth of a mile from the mine portal, a vein 4 feet thick is being developed by open-pit or quarry methods.

Of all the mineral produced at the property near Salida, approximately 20 per cent is picked, sorted, crushed, and shipped without further preparation as metallurgical spar for use in steelmaking. There are three grades of fluorspar: metallurgical, containing not less than 85 per cent calcium fluoride and not more than 5 per cent silicon oxide; ceramic, composed of 90 to 95 per cent CaF_2 and not more than 5 per cent SiO_2; and the acid grade, containing at least 97 per cent CaF_2 and not more than 2 per cent SiO_2.

Before 1938 there is said to have been only one fluorspar flotation mill in the United States, but since that time such plants have been built in nearly all producing fields. The mineral presents no unusual difficulties so far as flotation is concerned, and an advantage of milling is that ground spar can be made according to varying specifications for different uses. The Kramer mill was designed and equipped in its entirety by the Denver Equipment Company after preliminary study of local conditions and much research in the company's laboratory. Milling involves the elimination of silica—in this case it is reduced to 1.5 per cent or less—and drying of the concentrate to a moisture content of less than 1 per cent before shipping.

Operations were begun last October, and at present are proceeding in two shifts, the limiting factor being the amount of ore the mines can supply. Some is purchased, though no milling is done for others. The material is hand-trammed from the portal to storage bins, where it is moved by truck about 100 yards uphill to a Universal jaw crusher which reduces it to ¾-inch size, the largest dimension. Then it is carried by conveyor to a 160-ton, 16x16-foot

steel bin from which it is delivered by an ore feeder to an open-end type 5x8-foot ball mill. On its way to the latter, soda ash is added to the crushed ore for greater alkalinity, a pH of 8.2 to 8.4 being desirable.

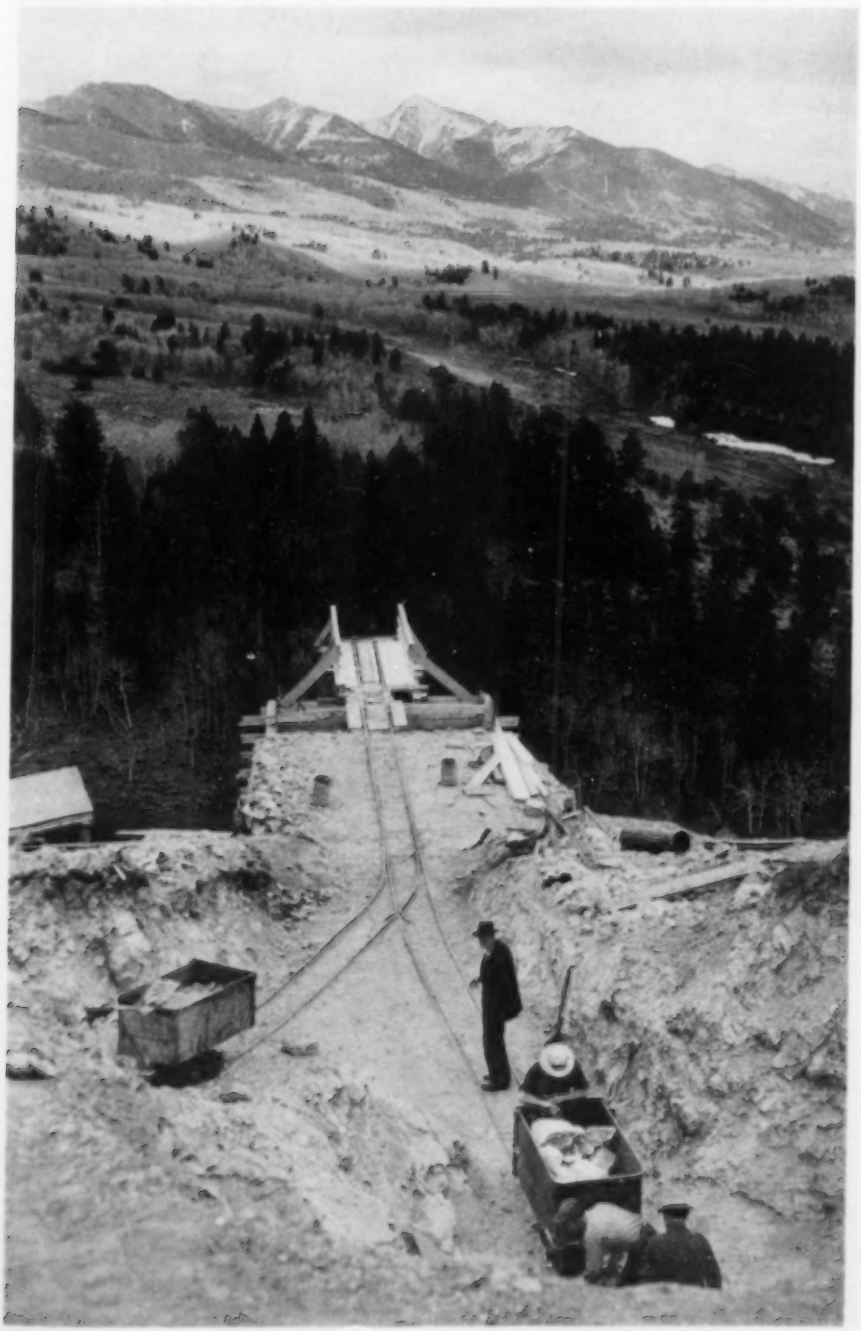
The ball mill reduces 95 per cent of the mineral to a fineness that will permit it to drop through a 100-mesh screen on its way to a barrel-type conditioner, a 3x14-foot Akins classifier passing the coarser 5 per cent back to the mill for regrinding. From the conditioner, where oleic acid and sodium silicate are introduced, the fine ore and water flows successively through three banks of six flotation cells each. Between the roughing cells and the first and second clean-up cells, it is occasionally necessary to add more oleic acid, the flotation agent. This acid tends to congeal in the icy water of the mountain streams from which the mill gets its supply, so a boiler was installed that heats 80 gpm. to a temperature of 80°F., warming all the water used in the plant.

Leaving the flotation cells, the concentrate enters an 8x16-foot thickener, where it is allowed to settle and the water is withdrawn. At that stage in the process the moisture content of the mineral has been reduced to 50 per cent. Thence it is transferred by a 3-inch diaphragm pump to a rotary filter consisting of an airtight iron drum, 4 feet in diameter, with a 2-foot-wide rim of 50-mesh stainless-steel screening. As the drum revolves slowly, its lower quadrant dips into the concentrate, a pump meanwhile maintaining the interior under a partial vacuum. This serves to remove more water and sucks the concentrate against the rim in a sheet—up to 2 inches thick—which is cut from the drum by a stationary blade. The concentrate next drops into an open-flame, oil-fired, 3x20-foot drier at the end of which it is collected and pushed by a screw-type conveyor into one of two 16x20-foot steel ore bins, ready for shipment. The moisture content is now less than 1 per cent, and from 84 to 85 per cent of the fluorspar content has been recovered. The metallurgical-grade spar can be shipped in open gondolas, but the ground, acid grade would be contaminated beyond use by soot and other dirt, so it must be transported in closed cars or containers.

As previously mentioned, the mill has been operating in two shifts only because the mines, until the recent Poncha Pass development, could not supply ore sufficient for three shifts. But when working on a 24-hour schedule, the capacity of the mill will be close to 200 tons daily, of which some 80 tons will be recoverable as ground spar. This is in addition to the 50 tons of metallurgical spar shipped each day direct from the crushers. A small crushing unit is to be installed at a railroad siding at Salida to handle fluorspar as it comes from Poncha Pass.

Arthur Flannigan, a veteran of twenty years in metal mills, is superintendent of the Kramer mill, with Bill Harrington foreman of the mines. Jack Warner is foreman at Poncha Pass.

Experts say that the Arkansas Valley should yield at least 50,000 tons of fluorspar this year. There is another 10,000 to 12,000 tons in Colorado, including the Wagon Wheel Gap operation which produces metallurgical spar for the Colorado Fuel & Iron Company. Most of the valley's output goes direct to eastern markets near the great iron and aluminum centers. About 40,000 tons is expected in 1943 from New Mexico, where the largest workings are those of the Zuni Milling Company. Scattered thousands of tons will come from other western states, and exploration and development work are underway at many points in and west of the Rockies. But so far Colorado and New Mexico are producing the bulk of the fluorspar in the region west of the Mississippi.



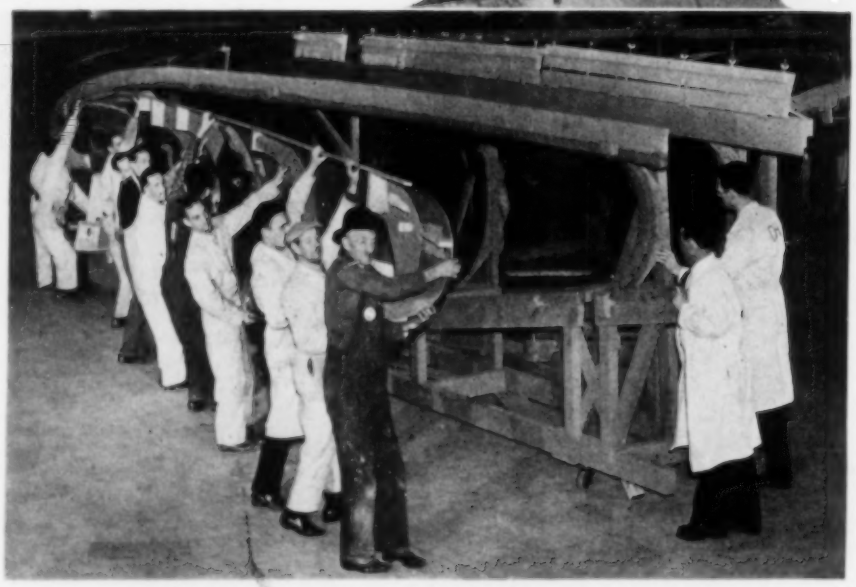
PONCHA PASS PROPERTY

Approximately one-third of the crude ore comes from an open-pit operation 18 miles from the mill and at an elevation of 9,600 feet. This picture shows the tracks leading from the workings to the storage bin from which trucks haul the material to the mill. The Sangre de Cristo Range is in the background.

Plane photo from British Information Services. Others from National Film Board, Canada.

Plastics and Plywood

*H. T. Moore and H. J. Vogler**



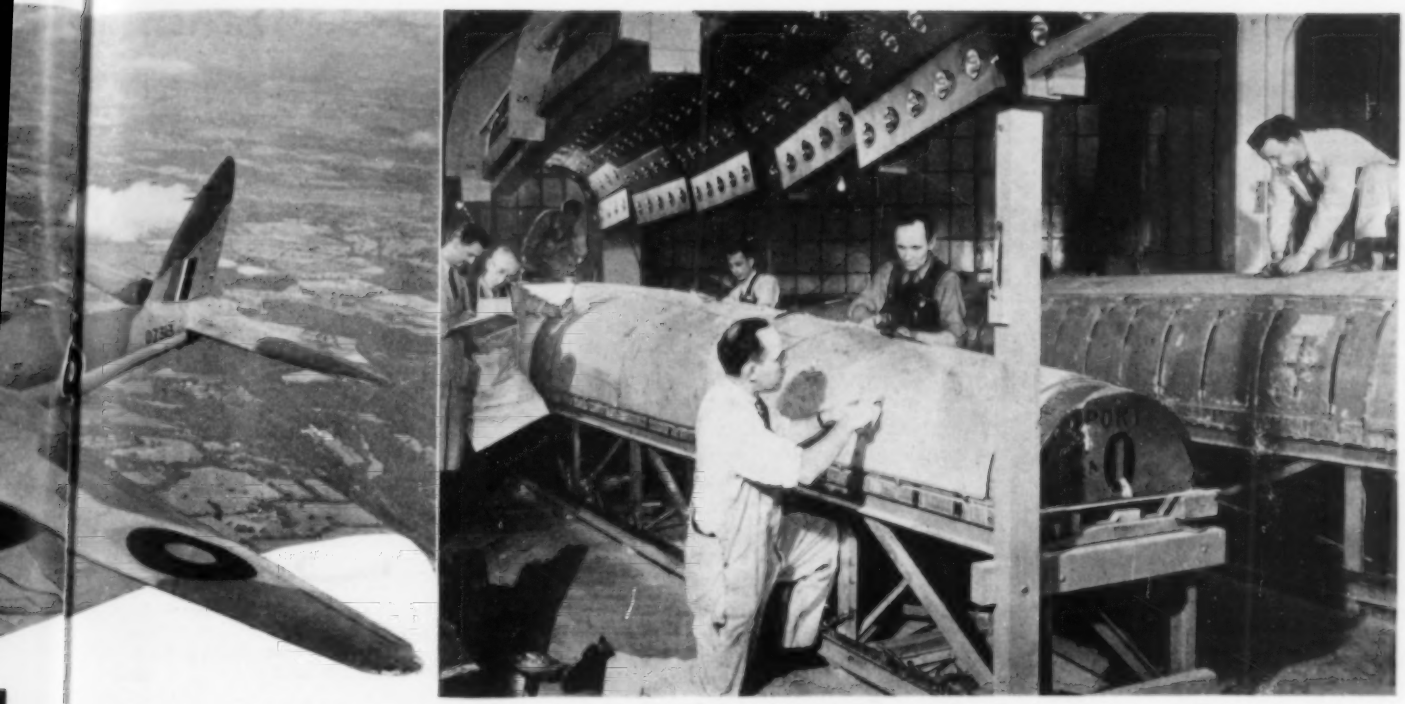
EARLY in the war, the limited supply of aluminum and magnesium alloys available for airplane requirements forced aircraft engineers to reëxamine plywood for structural use even though it had previously been rejected as unsafe. The assembled veneer sheets with longitudinal and cross-grain layers had adequate strength in two directions, but the earlier glues of casein or blood albumin were not waterproof, fungusproof, nor heat-resisting and were therefore too risky for structural purposes in war craft. Fortunately, the plastics industry supplied a possible solution of the problem by providing a durable resinous bond for plywood that, when set, is not subject to further reactions nor seriously affected by heat or cold.

The two principal types of plastic resins in commercial use are the thermoplastic, which becomes soft when heated, and the thermosetting, which acquires a permanent set when cured by heat but is not again softened by reheating. The thermosetting resins, which have the dependable characteristics needed for adhesion, are of two general types: the phenol-formaldehyde, which is largely used for hot-press gluing; and the urea-formaldehyde, which is suitable for hot-or cold-press plywood assembly. Many different varieties of resins are available, however, to meet the diversified requirements of the plastic-products industry.

Compression molding of plastic products was done extensively prior to the war by means of semiautomatic presses, and during the last few years fully automatic compression molding machines have been introduced commercially to perform routine quantity-production operations with a minimum of attendance. Pressure-molding of resin-bonded plywood into compound-curved surfaces for fuselage shells and other parts for small and medium-sized airplanes is accomplished under heat and pressure in a hot press or by means of a forming mold in a steam-heated chamber or autoclave. The forming mold or die, which is usually of wood or may be of steel for volume output, has the contour of the finished product desired. After coating the properly shaped strips of veneer or laminates with liquid-resin adhesive, the solvents are first evaporated at room temperature, which is below the curing or polymerization temperature of the resin. The strips are then bent over the forming mold and held in position by staples, tape, clips, or nailing strips. Additional plies or shaped pieces are next added and arranged differently to form simple or compound curvatures of constant or varying thickness. Beechwood faces may be applied to spruce cores, or other combinations may be made, depending upon the shape, size, and service of the part or design.

After the assembly has been carefully built up in tailorlike fashion and the veneers have been suitably fastened to the mold, pressure with heat is applied by press action or by the flexible-bag or fluid-pressure molding process. With bag-molding, internal or external pressure may be exerted by deflating or inflating a bag and by applying external or internal fluid pressure or vacuum, as required, with steam as the heating medium. Different techniques or modifications are used under the process names of Duramold, Vidal, Aeromold, or vacuum bag-molding. Flat plywood can

*Industrial and products engineers, Day & Zimmermann, Inc., Philadelphia, Pa.



MAKING MOSQUITO BOMBERS

The de Havilland wood-constructed bomber (above-center) is the fastest airplane of its class, with a speed of around 400 miles an hour. Groups of these planes raided Berlin by daylight and have been known to fly from Great Britain to Russia and back, leaving in the morning and returning the same afternoon. The Mosquito has a wing span of 54 feet 2 inches and is 40 feet 9½ inches long. It is powered by two Rolls-Royce engines, has four 20-mm. cannon and four .303-caliber machine guns grouped in its nose, and can carry a ton of bombs from England to any point in Germany. It made a design and construction record with its 22 months from drawing board to service. Mosquitoes are being built in the Dominion by de Havilland Aircraft of Canada, Ltd. The view at the right shows concrete forms over which the lengthwise half of a fuselage is molded from plywood. The sheets are held in place by pressure strips while the glue between them is dried with heat from the infrared lights overhead. The weight of resin-bonded plywood is deceiving. A completed half-fuselage is shown at the left. Such a structure weighs considerably less than its metal counterpart and is far stiffer, pound for pound, because of the fact that it is highly compressed. Skilled woodworkers help to construct Mosquitoes. Pictured at the upper left is George Martin, of Toronto, who was formerly engaged in putting together the fiber woodwork of moving parts of pianos.

be made by bag-molding, but the limited supply of rubberized fabric restricts the method to curved shapes or to parts that are manufactured in small quantities or are too large for standard-size presses.

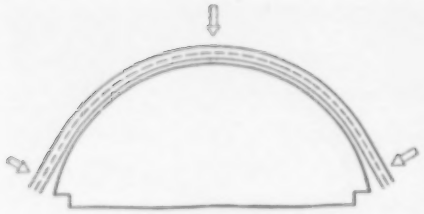
The hot-press method, which is fast and insures uniform results, is generally used for bonding flat plywood. As most resin adhesives require heat of from 240° to 300°F. for curing, hot presses are equipped with adequate ventilating facilities. The big molding presses must handle large volumes of work to justify the investment in hydraulic auxiliaries and metal dies.

Localized electric heating of the bonding adhesive is also being accomplished by means of high-frequency alternating current which reverses millions of times per second to produce the required heating effect. High-frequency tubes, resembling radio-tube transmitters, are housed in compact cabinets with the necessary transformers and condensers. The heat-output capacity of the tubes varies from 300 to 500 kw., but as the over-all efficiency of the electric-power conversion to heat averages 50 per cent, the electric input must be doubled to obtain the desired heating effect. The resultant "artificial fever" in the resin adhesive provides the temperature needed for the permanent set of the laminated plywood.

The high-frequency heating method can be used with existing presses by inserting metal sheets between stacks of wooden layers that have been coated with high-temperature resin. The metal sheets are connected to the source of electric power, while the press frame forms the other electric terminal. As the press compresses the plywood stacks the electric heat is applied, and in a few minutes the thermosetting action is finished. This process is much faster than steam heating, provided it is applicable to the shapes desired, and is the most successful method for thick plywood layers. It is also being used to preheat other plastic compounds before molding. Thick slabs of ground cork are being resin-bonded in this manner, and materials such as paper, cellulose, textiles, rayon, ceramics, and rubber can be electrically heated rapidly under time and temperature control.

The existing presses, ovens, vats, etc., were not made for electric heating, which is being applied with the facilities available. When new specialized equipment can be obtained, it will no doubt be designed with insulation correctly placed to avoid burns and shocks from high-frequency current. Further research is needed to heat uniformly plywood parts of varying thickness. On account of the heat problems and expense involved with the hot-setting processes, cold-setting glues are preferred for parts that can be reinforced independently or that do not require the full strength and durability of the more important structural members.

A number of the smaller airplanes built largely of resin-bonded plywood have been successfully used for training and limited combat service. The Fairchild AT-21 (known as the Gunner) is actively serving as an Army gunnery-crew trainer. An accompanying illustration shows a ground view of this 2-engine plywood plane, which has a wing spread of 53 feet. The fuselage consists of wood bulkheads covered by Duramold plywood, with the forward section supported internally by a welded-steel tubular truss. The wings are of 2-spar wood construction with wood ribs also covered with plastic-bonded veneers



BAG-MOLDING OF RESIN-BONDED PLYWOOD

Because standard types of hot presses exert their effective pressure in only one direction, and any angling or curved surfaces receive but a part of this pressure, there was developed the technique of flexible bag-molding to utilize pressure that is fluid and that is therefore exerted in a direction perpendicular to all surfaces against which it is applied. The fundamental principle involved is the use of an inflated or deflated bag forming one-half of a pair o molding dies. Since omnidirectional pressure is exerted, curvature and variations in veneer thickness cease to be disturbing problems and the pressure can consequently be of lower range. While effective pressures of the order of 60 to 80 pounds per square inch are usually adequate, proper consideration must be given to the partial pressure that is required to hold the layers of veneer snugly against the mold, and the highest practical pressure that can be applied with the equipment available is therefore desirable. The sketch indicates the effective pressure in the bag-molding of a curved plywood section. Compressed air often serves in the initial stages of bag-inflation, while hot water or steam is used during the subsequent stages to furnish the necessary heat for curing the resin adhesive.

molded to the required curvature. The exterior is finished with a resinous aluminum paint, which gives a surface appearance of polished metal, while the interior has a clear varnish finish with a resinous base.

The British and Canadian contribution to wood-frame-and-plywood reconnaissance bombers is the fast-flying de Havilland Mosquito, which has a span of 54 feet 2 inches. These planes are equipped with two Rolls-Royce Merlin engines and easily travel 400 miles per hour. When used as fighters, they depend upon speed and maneuverability rather than armor for protection. They are credited with the daylight bombing of Berlin and canceling of the Luftwaffe anniversary speeches of the "Goering Gang." When forced down at sea, the Mosquitoes have floated for many hours and improved the crews' chances of being rescued. When structural repairs are needed, it is a job for experienced carpenters.

The war industries are utilizing the available plywood capacity, but the field of usefulness of this lightweight, high-strength, durable material will expand greatly in the postwar period when standardized methods and lower costs will be realized. Another molded plywood application is in the construction of hulls for landing barges and other small craft. Hulls up to 25 feet and longer are being formed by the bag-molding method, and some are assembled of plywood sheets 8 feet wide by 80 feet long. The ribs and framework are made in part of plywood. These boats and life rafts have proved to be seaworthy and free from shrinking and caulking difficulties. Light portable pontons, ramps, and walkways for the building of temporary bridges also are being made of molded plywood.

Plastic-plywood panels, flat or curved, are entering into the construction of prefabricated houses, partitions, trailer bodies, refrigerator and railroad passenger cars, store counters, furniture, lockers, and numerous other things. Resin-bonded plywood is meeting other needs by serving as a backing for miscellaneous materials or as a surfacing. Sheet metal, cloth, asbestos, paper, vulcanized fiber, or sheets of plain or laminated plastic can be bonded to the plywood face to provide exterior surfaces for special uses.

The difference between plastic-bonded plywood and resin-bonded laminated wood is chiefly in the arrangement of the veneers for strength requirements. Plywood has the veneer layers assembled lengthwise and crosswise for strength distribution and warp resistance, while laminated wood has the grains parallel to provide greater tensile strength in a single direction. Propellers and some of the spars and framing members in light airplanes are being made of laminated wood instead of metal or solid spruce. Beer barrels of the future are expected to be lighter when the staves are of laminated wood. Life rafts are being built of laminated balsa wood with plywood flooring. The bonding of plywood and laminated wood for structural needs is another application awaiting further development.

High-density plywood differs from molded plywood in the kind of glue used, the method of forming, and the physical characteristics. The assembled veneers are impregnated with a low-polymer water-soluble resin and compressed while at curing temperature between metal dies or plates under pressures up to 1500 pounds or more per square inch. By impregnating the veneers with resin before coating them for gluing and assembly, the wood is more impervious to moisture after bonding. When compressed, this high-density or "compregnated" wood has higher tensile and compressive strength and glass hardness than molded plywood, as well as greater resistance to abrasion, moisture, swelling, shrinkage, and acid corrosion. Being more homogeneous, its strength characteristics are more uniform and better controlled than those of the less-expensive molded plywood.

U. S. Plywood Corp. photo.

PLYWOOD SEAT

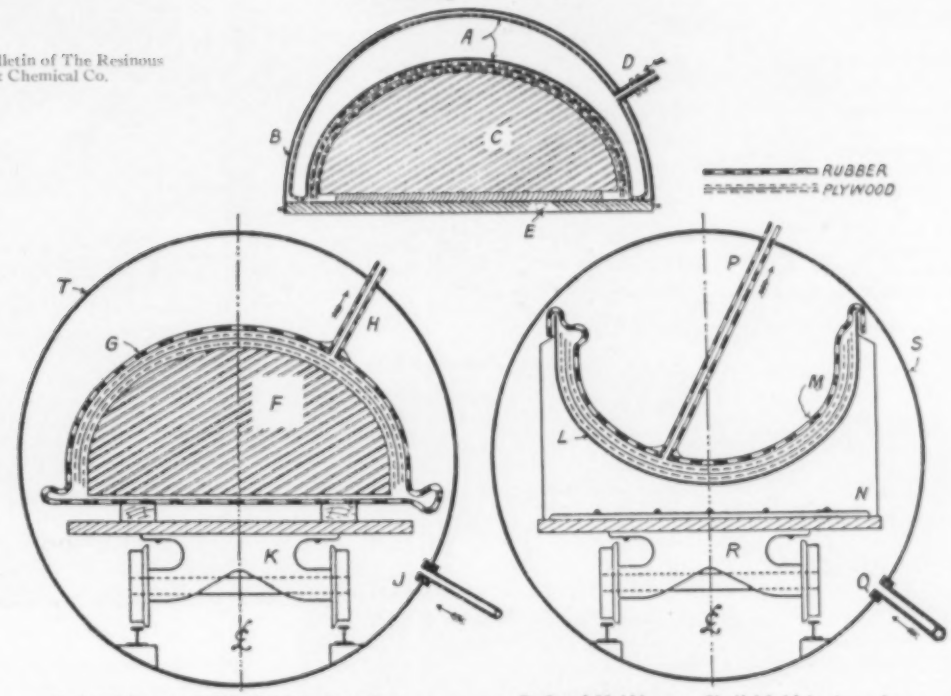
Striking evidence of the manner in which plywood may be molded is this airplane seat that was formed from one piece of material.

FAIRCHILD AT-21

A 2-engined, plywood plane that is used as an Army gunnery-crew trainer. It has a wing spread of 53 feet.

Inflated Bag on Solid Mold

From a bulletin of The Resinous Products & Chemical Co.



Deflated Bag on Solid Mold in Autoclave

Deflated Half-bag on Shell Mold in Autoclave

A: Inflated rubber mattress.
B: Half steel shell to restrain mattress.
C: Solid mold, wood or metal.
D: Fluid pressure inlet to inflate mattress.
E: Base plate, to which B is bolted.
F: Solid mold, wood or concrete.
G: Deflated rubber bag.
H: Vacuum or vent connection.
J: Fluid inlet, to produce pressure in autoclave.
K: Transfer car.
T: Autoclave.
L: Shell mold of metal.
M: Half-bag to be deflected.
N: Cross frames to keep mold, L, rigid.
P: Vacuum or vent connection.
Q: Fluid inlet to produce pressure in autoclave.
R: Transfer car.
S: Autoclave.

METHODS OF BAG-MOLDING

A shape such as a boat hull or a half-fuselage of an airplane may be molded as shown in the top sketch. The layers of wood, with adhesive between them, are successively laid against the solid mold *C*. An inflatable rubber bag, *A*, is placed over the outer veneer, and this is followed by a semicylindrical steel shell, *B*, which is bolted to the base *E*. The bag is then inflated through *D* with steam, hot water, or compressed air, forcing the layers snugly against the mold and holding them there until the bond is completed. The sheets of veneer are properly tapered before assembly so that all edges and ends fit closely. Another and newer method of molding a similar shape is illustrated at the lower left. Here the convex mold *F* is placed with the overlaid plywood inside the bag *G*. The air within the latter is exhausted through the vent *H*, to which vacuum may be applied. The whole assembly, loaded on a transfer car, *K*, is run into an autoclave or cooker, *T*. The interior of the autoclave is filled through *J* with the fluid pressure medium, thus exerting equal pressure to all the curved plywood surface. A third process is shown at the lower right. In this case a thin-metal concave mold, *L*, is utilized, its contour being braced by frequent cross frames, *N*, which, in turn are bolted to the platform of the transfer car *R*. As the outer or convex side of the plywood is against the metal mold, a more streamlined surface is obtained than with either of the first two methods. Another difference is the use of a half-bag, tightly clamped all around the edges and ends of the metal mold *L*. The mold then serves as half of the bag, thus eliminating the lower half, as seen at the left, and any damage to which it might be subjected. The mold, however, must be airtight. The vacuum connection at *P* functions as described. By this procedure heat is applied to both sides of the plywood through the rubber *M* and the thin steel mold *L*.

High-density plywood is already competing with metal in certain fields. Propeller blades and the revolving blades of cooling-tower fans are being made of compressed woods, in some instances replacing aluminum, magnesium, and stainless steel. Other dense-wood products being manufactured or contemplated include airplane-spar reinforcements, struts, bushings, fuselage and wing coverings, gears, hand-truck wheels, gunstocks, furniture, bobbins, shuttles, spools, bolts, nuts, screws, washers, and other miscellaneous articles. Compressed plywood is being considered for floors where acid or alkali conditions are present, or for insulating panels or enclosures for electrical apparatus.

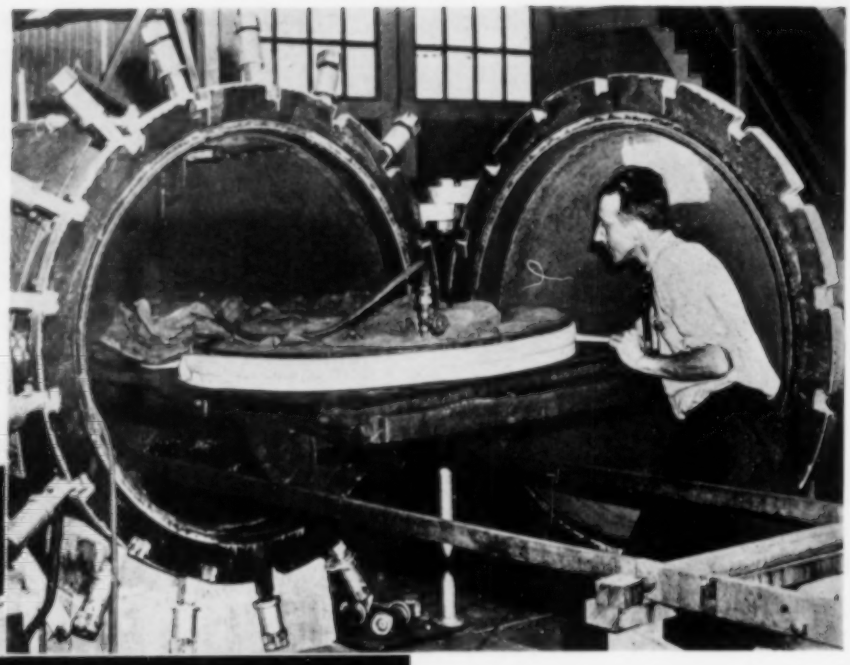
Obviously, cost will be the economic factor controlling the future use of both molded and high-density plywood. However, with volume output a certainty, relatively low unit costs are to be expected. A considerable amount of research is urgently needed to insure uniformity of quality, to improve and standardize production methods, and to assure safety and dependability in stress and strain calculations for broader structural applications.

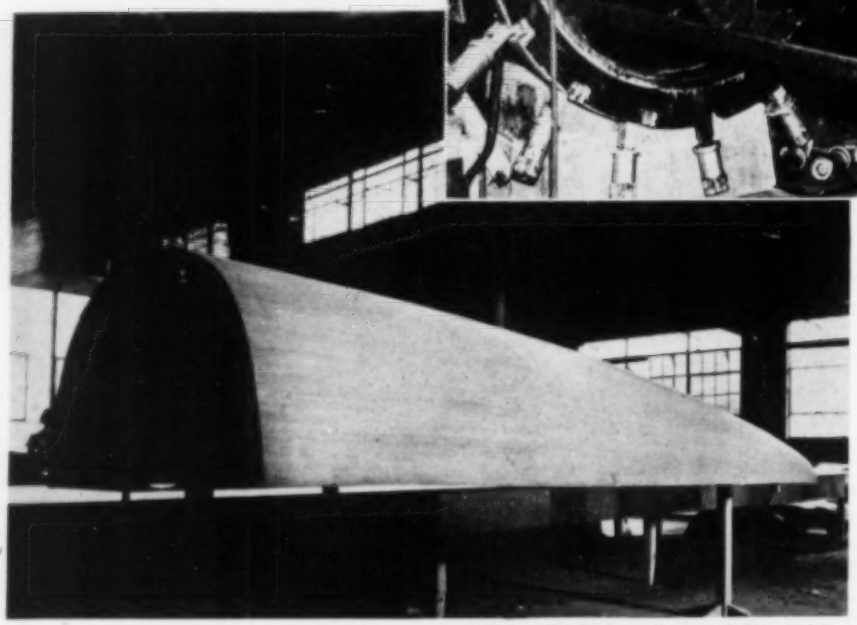
The paper industry has also responded to the war demands for new materials and, as a result of prewar research, is making an outstanding contribution by supplying substitute products of superior quality. In consequence, a new line of durable goods will be available in the postwar world. The molding under pressure of laminated high-strength paper of suitable thickness and impregnated with liquid-plastic resins is providing an improved type of fiber that has unusual strength characteristics with relative lightness, although it is somewhat heavier than molded plywood. It is being made from a special wood pulp and formed in presses with a new resin at the relatively low pressure of 75 pounds per square inch. Tests have proved that it has a strength-weight ratio comparable to that of aluminum. It is being molded into flat or curved panels, tubes, and structural shapes.

When used for airplane wing tips, the ribs as well as the surface of the tip are formed from a single paper blank. Published claims credit the entire wing-tip

BAG-MOLDING TECHNIQUE

Using what is known as the Vidal process, the mold and plywood for a half-fuselage are placed inside a rubber bag and run into a pressure vessel that is also an oven (right). By a combination of pressure on the outside and vacuum inside of the bag, the assembly is shaped and the heat sets the resin adhesive to hold it as formed. Below is shown a half-fuselage that has been "pressure-cooked" from Tego bonded plywood.





Photos, The Resinous Products & Chemical Co.

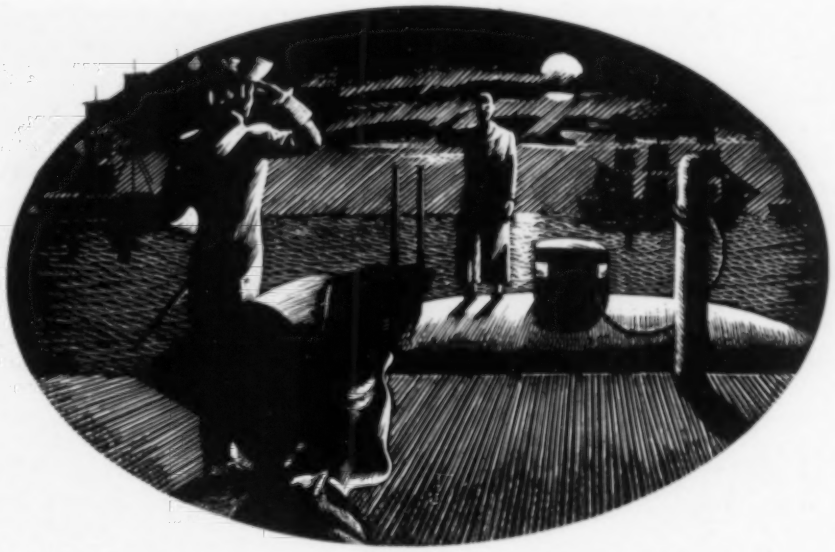
structure as having thirteen paper-plastic parts, as compared with 96 for a similar unit of plywood or aluminum. Paper-plastic wing tips are said to possess additional advantages over those of aluminum: namely, a smoother surface, which does not require coating or finishing; greater resistance to abrasion or denting; and less damage when penetrated by a bullet, the hole being round and smooth and not jagged.

The field for this durable type of paper-plastic fiber is extensive, as it competes with the paper industry's existing fiberboard, with molded and laminated plywood, with other plastics, and for some purposes with light structural metals such as aluminum, magnesium, and alloy steels. Among some of the products for which favorable claims have been made are: Fiber containers, which have successfully withstood immersion in water, as well as prolonged exposure in all kinds of weather. Paper bags can be used for packing and shipping hydroscopic chemicals, hot asphalt, grease, plastic resins, etc. Baking dishes, water-tank insulators, and paper blankets will be available for the home. And there will be pots or cans for oil, glue, paint, lacquer or rubber cement, cups, dishes, and many other molded articles.

The spectacular development of the plastics industry has caused some alarm among manufacturers of metal products, visualizing, as they do, postwar competition. The substitution of plastic or plastic-bonded parts for metal will be largely a problem of economics, public preferences, and availability of materials. The field for plastics is obviously limited by their physical characteristics and by the practical production methods. Alloy steel, aluminum, and magnesium alloys will have their overlapping applications and may compete in some lines with plywood and other plastic products. But where hardness, dimensional stability, exceptional strength, or microscopic accuracy are required, there metal will still have the preference.

The outstanding properties of plastic products are: They combine in one material and operation several desirable features such as forming a single part with few or no joints, molding special shapes, and obtaining a finished surface that is plain or colored in appearance. Metal die castings that have the molding advantages of plastics and also require minor finishing operations are still preferred for certain uses, especially where strength is a factor. A 1-piece plastic molding may combine insulating, housing, and structural properties that facilitate mounting electrical connections or equipment. The relative lightness of plywood with its favorable strength-weight ratio, and the wide color range of plastics from opaque to crystal transparency, are desirable characteristics for other products. In the chemical industry, plastic tanks, pipes, and connections are resistant to acids, alkalies, or solvents, and are being extensively used for that purpose. These synthetic products are poor heat conductors and are therefore suitable for making handles and other heat-resisting articles. The chief limitations are the restriction in the size of the molding imposed by the temperature-control problem, which can be partly offset by the assembly of plastic parts and by the large investment required in presses and dies.

The field of plastics is still expanding, some of the newer products including floor coverings and protective coatings for metal, as well as for combinations of metal or plastic parts with laminated plastic or plastic-bonded plywood. With automatic compression molding; injection molding for thermoplastics comparable with metal die-casting; transfer molding or double-heat application for first softening the thermosetting plastic in one chamber of a press and then transferring it to a second chamber for hardening and final shaping; and with the extrusion of rods, tubes, bars, and shapes of thermosetting resins, it would seem that the plastics industry is moving full speed ahead.



A Submarine in New York Harbor in 1776

BECAUSE the submarine is usually regarded as a comparative newcomer in naval warfare, most people do not realize that its beginnings date back more than 300 years and that an American underwater vessel actually attempted operations against a British man-o'-war in 1776. Had the attack succeeded, the development of the submarine probably would have been much more rapid than was actually the case; yet, ironically, the failure was in no wise due to imperfections in the attacking craft itself.

The eighteenth-century submarine was the brain child of David Bushnell, a young man who had but recently graduated from Yale College. Few of the naval weapons that now seem commonplace had not even been dreamed of then. But Bushnell, who had already proved that gunpowder will fire underwater, conceived and constructed a submergible vessel which, though crude, actually embodied principles in use today.

In 1776, a hostile British fleet lay at anchor in New York Harbor. The self-propelling torpedo had not been invented, but young Bushnell proposed to rig a mine to his 1-man boat, travel underwater to a point beneath one of the enemy ships, and fasten the mine to the hull of his quary. The mine, an ingenious device containing 150 pounds of gunpowder, was to be fired by a timing mechanism.

Bushnell's submarine, built of wood, was called the *Turtle*, probably because in shape it resembled that slow-moving animal. It had a small conning tower that accommodated the operator's head and shoulders. Glass windows provided visibility. Completely watertight, the strange vessel held enough air to sustain a man for 30 minutes. Two ventilating pipes, which automatically closed as the boat submerged and opened when it surfaced, gave access to fresh air.

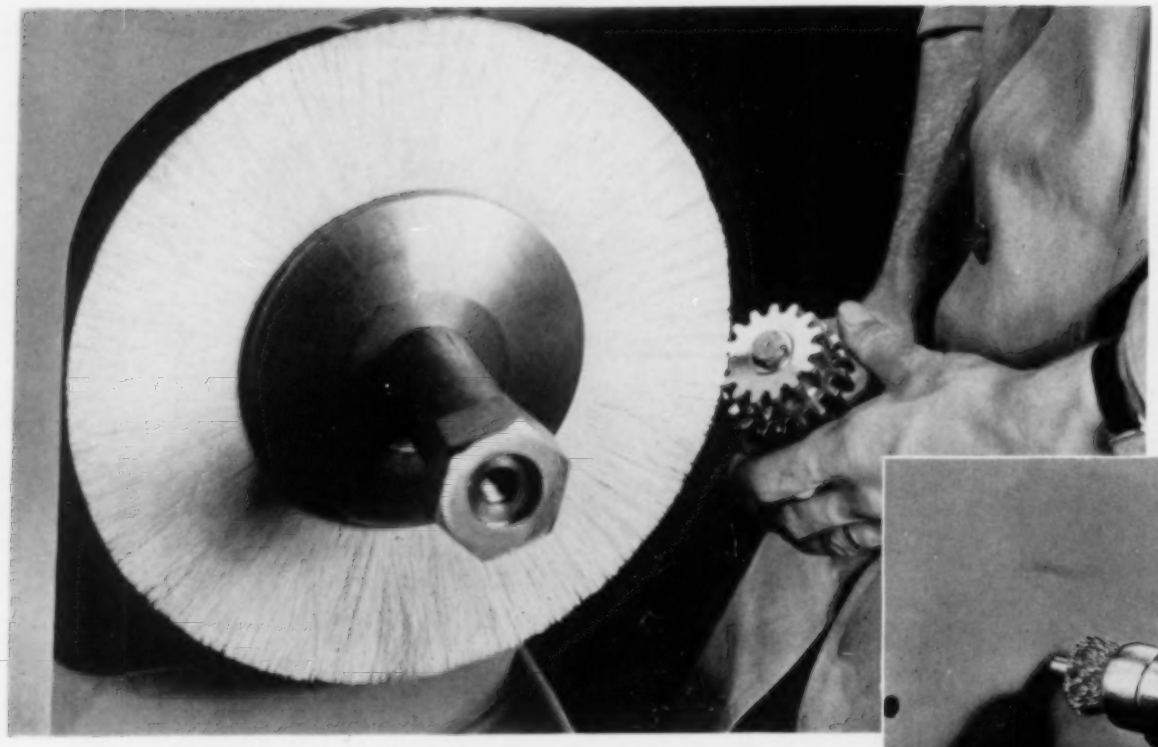
To submerge, the operator depressed a brass foot valve, thereby admitting water into the hull. To ascend, he worked two brass forcing pumps that discharged the water. Forward or backward travel was made possible by the action of a screw propeller on a shaft rotated by hand or by foot. This enabled the submarine to make 2 or 3 knots either ahead or astern. The craft was also provided with an auxiliary, crank-operated vertical propeller and with a rudder for steering. On the bottom of the hull was lead ballast. This was held in such a way that 200 pounds of it could be dropped in case rapid surfacing was necessary.

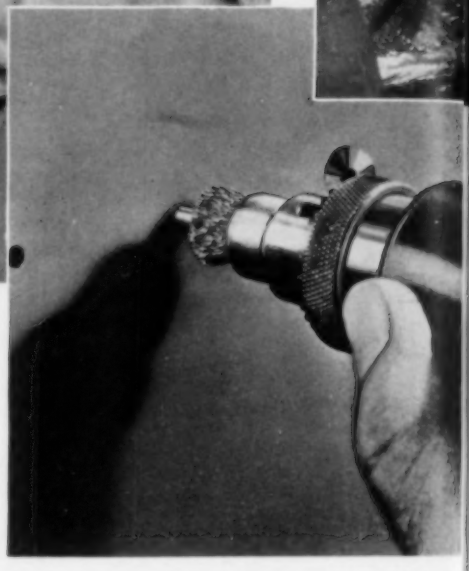
As interesting as the submarine, itself, was Bushnell's proposed method of conveying the explosive and attaching it to the hull of an enemy warship. Near the stern of his vessel, just ahead of the rudder, he had built a receptacle that would hold a keg of powder. As a means of fastening the latter to the wooden hull of a ship, the inventor had provided an iron screw that could be turned from within the submarine. The purpose of this screw was to anchor the powder keg to the foe's vessel by a short length of rope. Once the mine was detached from the submarine, the timing device would begin to operate and the sub could withdraw to safety.

According to an account published in an advertising folder of Badger Paper Mills, Inc., of Peshtigo, Wis., Sergeant Lee of the Connecticut Regiment piloted the *Turtle* in an abortive nocturnal attack against the man-o'-war *Eagle*. If this version is to be credited, Lee was unable to attach the mine because the iron screw could not penetrate the *Eagle's* copper sheathing. An hour passed as the watchers on shore gazed eagerly across the water, not knowing that Lee had failed. Suddenly a tremendous explosion rocked the harbor and a huge column of water geysered upward. The mine, released from the submarine, had exploded harmlessly far from the British gunboat. Properly placed, it would have sent the enemy craft to the bottom.

Apparently, this failure retarded the development of the submarine for the better part of a century. But David Bushnell continued his experiments with mines and developed a floating variety that exploded when struck by a ship. One of these floaters, intended for the frigate *Cerberus*, blew up a captured schooner instead. Nevertheless, Bushnell's mines are said to have been mechanically perfect, and they established a principle that is still being used in naval warfare. But like many other inventors, Bushnell was unable to win governmental support for his ideas, and he went to France soon after the war with Great Britain. For years it was thought that he had died in the French Revolution; but long afterward he was discovered in Georgia practicing medicine under an assumed name.

Who knows how the *Turtle* might have changed the history of the world if its attack upon the *Eagle* had succeeded? In that event, submarines might have become commonplace implements of war by the beginning of the nineteenth century. Perhaps it is just as well that the attempt was a failure; that the world was spared, for a time at least, the barbarities made possible by undersea warfare.





Smoothing Out the Rough Spots

Vernon E. Brink

A MILITARY plane costing $50,000 has more than 1,000,000 rivets and numerous other metal-to-metal connections every surface point of which must be cleaned and polished before actual welding or riveting can begin. Machines that perform these surfacing jobs and thousands of other smoothing operations are called industrial power brushes, and so vital to modern industry have they become that, were their manufacture suddenly to cease, our war program would be seriously handicapped.

Nearly every piece of metal, whether it is stamped, drilled, sawed, flanged, milled, punched, cast, or welded, has rough edges. Precision work, on which so much depends today, necessitates their removal, and it is largely the task of the brush engineer to solve these problems of production as they arise. Today there are available in excess of 5,000 types of power-driven brushes, and hardly a day passes in which a new one for a new use is not developed. The Osborn Manufacturing Company, the world's largest manufacturer of such brushes, alone has devised more than 100 different kinds in the past eighteen months to meet the many and varied requirements of the present emergency.

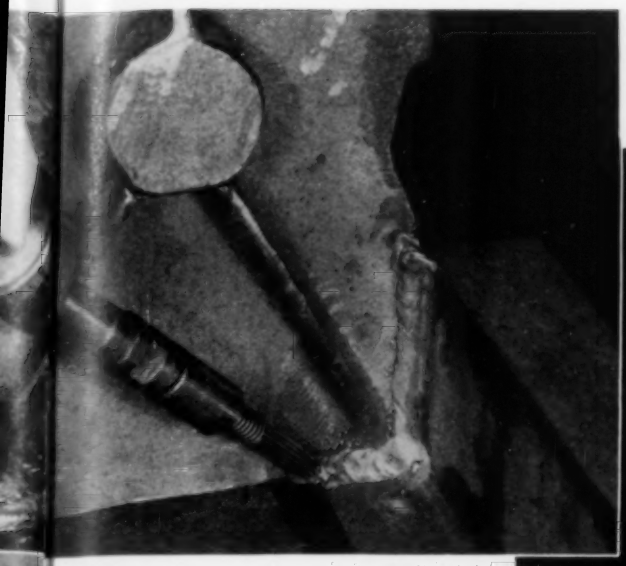
The replacement of power-operated brushes for the old time-consuming methods of hand-brushing and hand-scraping has resulted in great savings in time. For example, welding in shipyards has been speeded up 100 per cent and riveting in aircraft plants as much as 1,000 per cent. The brushes, which may be classified under the head of secondary machine tools, range in size from one no bigger than a finger and weighing less than an ounce to one 22 feet long, 2 feet in diameter, and weighing 1,000 pounds.

One of the most significant advances in this field is the increasing trend towards the use of compressed air for operating the brushing tools. This is probably attributable to the fact that, so powered, they are highly flexible and can be utilized for long periods without fatiguing the workers. Their widespread employment, together with other pneumatic tools, particularly in the aircraft and related industries is an indication that they are helping them to reach new "highs" in war production.

The materials from which the bristles are made are of a wide variety. Some are manufactured of steel, brass, or aluminum wire ranging in thickness from 0.0025 to 0.09 gauge; others are composed of cotton cord. Hog bristles, formerly imported from China and Russia and now obtained from domestic sources, are needed for certain brushes, while still others have fiber and plastic bristles. One of the newest kinds has nylon bristles only 2/1000 inch in diameter. It serves to remove rough edges from bomb sights.

In studying airplane crashes, scientists have discovered that some were directly traceable to the presence of tiny scratches or nicks in metal parts. It was found that these grooves or burrs, which remained after machining, developed into cracks under vibration. In the case of one such accident, investigation revealed that a propeller blade that had been rough-machined but never polished had broken at the shank end. In consequence, there were rough tool marks on the surface at that point, and these started the break and led to the crack-up. Being inaccessible, they could not be eliminated by the ordinary polishing methods, and something had to be devised to do the finishing.

A small brush made of Tampico, a tough fiber obtained from the century



plant that grows abundantly in Mexico, solved the problem. The plant, from which Mexicans obtain *tequila*, an intoxicating drink, is stripped of its leaves, which yield a fiber that is dried and made into rotating brushes in the form of cylinders or flat disks. Powdered alumina, fine enough to go through a 240-mesh screen and suspended in a pasty material, is used with the brushes as a polishing compound. The introduction of this new tool has had a twofold effect: it has eliminated the danger of metal cracks in our fighter planes and has reduced the time required to polish a connecting rod, for example, from a full day to about half an hour.

Special brushes 14 inches long and 6 inches in diameter are serving to keep open and free of corrosion thousands of miles of 6-inch pipe lines by means of which America's war industries are being supplied with liquid fuel and gasoline. Built of alternate sections of brush and metal washers, these go-devils are propelled through the lines with compressed air and at a speed of about 4 miles an hour, or the average walking pace of a human being. According to R. O. Peterson, director of technical development for The Osborn Manufacturing Company, "Whether pipe lines carry oil, gas, or other materials, there is always a sludge that forms on the inside of the pipe. If this is not removed periodically, the pipe lines cannot be operated at full capacity, to say nothing of the sludge contaminating the materials to be moved."

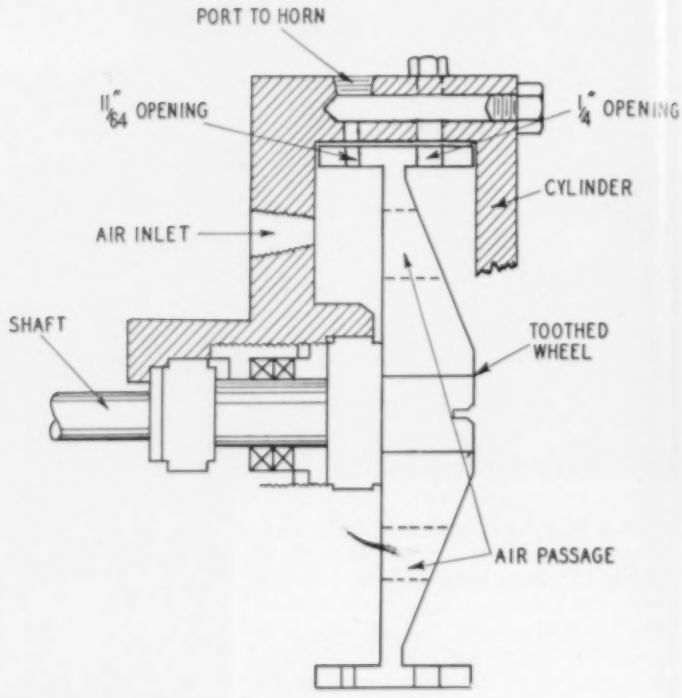
Power-driven brushes likewise are helping to rebuild worn-out tires—in short, to keep the nation's millions of automobiles on the road. These brushes have "rope-twisted" strands with needle-point wires that enable a mechanic to come in contact with every part of a tire without injury to the fabric and to form a far more adhesive surface for the application of the tread than it was possible for him to obtain with previous types of roughing tools. Power-driven brushes are responsible, too, for the art of printing on cellophane. Special brushes have been developed with which to prepare the surface of the sheets, and not until this was done could they be made sufficiently adhesive to take printing ink. Furthermore, women's shoes are smaller and daintier because of them. In the manufacture of shoes, it has heretofore been necessary to allow extra room for stitching the soles, thereby increasing the size. Today, by roughing the leather or rubber with brushes, the soles are cemented together.

Power brushes have come a long way since the time of Eli Whitney's cotton gin, which is generally considered to be the forerunner of these all-important tools, for without them aircraft manufacturers, munition-makers, shipbuilders —virtually every wartime producer in America—would be handicapped in keeping our soldiers on the fronts supplied with fighting equipment.

A FEW OF MANY TYPES

Industrial brushes are made of many different materials. The finest of all fibers used in Osborn brushes comes from a Mexican cactus called Tampico. A Tampico brush is shown at the top, left, cleaning and removing machining burrs from a double gear for an aircraft engine. A stiff and totally different kind of brush is the one pictured at the top, center. This one is designed to get into angles and corners to clean slag from welds. Another type for cleaning small areas around rivet or bolt holes to assure a good metal-to-metal contact is illustrated at the bottom, left. More than 1,000,000 such cleaning jobs are involved in the construction of a single large metal airplane used for military purposes. In tire-recapping much depends upon furrowing the old surface of the casing to insure a good bond between it and the "camelback" strip applied to it. Special brushes such as the one seen above perform this work satisfactorily.

Everybody in Boise Can Hear Air-Operated Siren



INSTALLATION AND STRUCTURAL FEATURES

The siren that is operated with compressed air and can be controlled to give either short or long loud blasts. The sound is emitted from the lower horn; the top one serves only to intensify it and to cause it to travel farther.

ENGINEERS of the Idaho Power Company abandoned strictly technical phraseology when they described the new air-raid siren which they designed and constructed as one "shaped like a morning-glory and fed by compressed air chopped up and expelled in pieces." Holding to the "pieces" conception, air impulses issue from a port and set up vibrations producing a sound 1,000,000 times that at the threshold of audability—the slightest sound that can be heard. It is beyond the threshold of feeling, for persons who have stood near it when blown say that the sound hurts the chest as though someone were standing on it.

The siren was designed by J. F. Emery and Leonard Walker, engineers of the power company. When the Boise civilian-defense authorities were trying to find a suitable air-raid signal system, they encountered difficulties. They could not locate anything loud enough and, at the same time, capable of control so as to sound short and long blasts to indicate an "alert," a "blackout," and "all clear." The reason was that they had been trying types that pump their own air. So the engineers set to work on the problem and produced one operated from an outside air source. In comparison with other daytime noises such as radios and automobiles, it gives a satisfactory alert warning within a radius of a mile. Under favorable conditions it has been heard 13 miles away.

Henry W. Young

In the new siren the air is released through one port, whereas the ordinary type has a number of ports through which the air escapes. Furthermore, the latter has no horn to serve as a coupling between the sound unit and the surrounding air. The Boise siren has two horns, in fact, and these send the sound out horizontally rather than vertically. The accompanying sketch and photograph give a fair idea of its structural features.

The sound unit consists of a wheel with two rows of 23 and 30 teeth, respectively. This wheel fits snugly in a steel cylinder and is rotated by an electric motor. Compressed air, supplied by a small compressor at the siren station, is admitted to the cylinder and escapes through the single port in impulses as the openings between the teeth come in line with the port. The impulses are produced at the rate of 450 a minute. The resultant continuous sound issues from the lower horn, which is attached to the sound unit, and impinges against the upper horn, which serves as a deflector and causes it to spread out horizontally.

To assure instant action in the case of an alert, the unit is provided with an electrically actuated valve that is opened and closed by remote control from the desk of the company load dispatcher. Morning, noon, and night signals are blown automatically four times daily through impulses from a "Telechron" timer located in the service building, so there is no question as to who's going to blow the whistle or whether or not these routine signals will be sounded.

The siren is mounted on top of a building where it is exposed to the weather. Theoretically, the upper horn, which acts also as a roof, prevents rain from getting into the lower one. Actually, this is not true, as some water blows in and collects in the neck of the lower horn. However, this does no harm by reason of the fact that the air pressure is high enough to expel any accumulation when the whistle is blown, as one engineer who stood near it after a rain learned to his dismay. But as snow, ice, or frost might give trouble, this contingency has been provided for by the installation of an electric heating element in a housing surrounding the sound unit.

The length of time the siren can give its warning signals is determined by the capacity of the air compressor. The machine now in use is equipped with a receiver and supplies sufficient air to blow the siren continuously for about five minutes. Then it has to pause to give the compressor a chance to catch up, for the signaling system requires 200 cfm. while the compressor furnishes only 100 cfm.

Compressed Air Institute Photos

Air-Powered Equipment Aids Invasions

IT HAS been reported that the first piece of mechanical equipment taken ashore when American troops invaded North Africa was a portable air compressor with its complement of tools, and that they were in operation by the time the first contingent began to land. Similar stories have filtered back from some of the invasion points in the South Sea Islands. They are probably true, for air-operated equipment renders important service in establishing footholds for thrusts of these kinds.

One of the principal uses of such equipment is that of drilling blast holes to remove rock in leveling off sites for airfields. However, many types of tools other than rock drills—including saws, grinders, riveting hammers, and chippers—are employed for either demolition or construction purposes. Airports are located so that planes can be based within easy bombing range of the enemy. More often than not they are in isolated areas where the only power available is that which the engineers take along with them.

These airfields are not makeshift affairs. They must support heavy loads, both when bomb-laden planes take off and when they land with considerable impact. Clearing and smoothing off the terrain, laying some type of hard surface, and digging drainage ditches are all operations that must be done effectively and with dispatch. One a field is in service, planes must be overhauled and repaired, and many air-operated tools are needed in this work.

Portable compressors are well suited for furnishing the power for these various purposes because they are compact, self-contained units mounted on wheels and therefore readily movable over any sort of surface that a truck can negotiate. They are driven by internal-combustion engines using gasoline or diesel oil for fuel. Large numbers of these machines are included in every military expedition of appreciable size. Since air-operated tools are widely used in building planes, it can be said that compressed air sees the job through by helping to prepare their bases and by keeping the planes in serviceable condition.

TWO TYPES OF AIR POWER

Tools powered by compressed air perform indispensable services in building military aircraft. Air-operated drills and paving breakers excavate rock to level air-base sites, to dig drainage ditches, and to provide foundations for essential structures. When an airfield goes into service, numerous pneumatic tools are used for repairing and maintaining the planes. Thus, compressed air on the ground works hand in hand with air power in the skies.

Nonreflecting Glass

IF YOU have ever browsed around in an art gallery you will know that pictures protected by glass have to be viewed from just the right angle, depending upon the reflected light. Jockeying around for a favorable position from which the whole painting can be viewed at a glance is an annoying but minor matter compared with being blinded momentarily by reflected light in the case of an automobile windshield, for that may lead to an accident.

Now we learn that the habitue of the art museum and the motorist can look forward to a day when they can pursue their pleasure and business free from troublesome glare because large sheets of glass and similar materials are, for the first time, being made nonreflecting by a new surfacing treatment. The technique was developed by H. R. Moulton, assistant research director of the American Optical Company. The chemical composition and method of application remain a military secret and are confined exclusively to war matériel. After fighting ceases, we are promised nonreflecting glass not only for windshields and pictures but for many things, including eyeglasses, camera and instrument lenses, faces for watches and clocks, show windows and cases, and dashboards for automotive vehicles and airplanes.

TREATED AND UNTREATED

This picture shows H. R. Moulton with an oil painting covered partly with light-reflecting and partly with nonreflecting glass. The obscuring and revealing effects of the two are plainly evident. The light normally lost through surface reflection amounts to about 8 per cent, and most of this is saved by the new surfacing method.

Sharing Knowledge

THE war has notably tightened the bonds between the Americas, and it is the function of the Office of Inter-American Affairs to see that our nation does its part in drawing us still closer to our neighbors to the south. This cannot be done solely by exchanging goods. To have a lasting community of interest, there must also be an interchange of ideas.

South America is a continent of vast resources and relatively small population. Its future prosperity must come largely from technological developments. Scarcity of shipping has forced South Americans to provide for themselves many things that they formerly procured from the United States and Europe. Engineering and industrial activity has therefore received an enormous stimulus —a trend that will no doubt continue after the war.

One result of this movement is a demand for more engineering knowledge, the so-called "know how" that has been acquired in this country through experience in many lines of endeavor. To fill this want, arrangements have been completed whereby up-to-the-minute technical information will be shared among the Americas through the translation and exchange of technical papers. Under the direction of the Division of Engineering and Industrial Research of the United States Academy of Sciences, important scientific articles by authorities in the United States will be translated into Spanish and Portuguese and distributed to individuals or published in engineering journals in the other Americas. To collaborate with the Academy, there has been set up a joint committee from the leading national engineering societies that will send digests of papers prepared by its members to similar societies in South America so that they may select the articles they desire. Like steps are being taken in South American countries.

In addition to the exchange of ideas on paper, participation in international engineering meetings are contemplated, as well as personal collaboration in technical problems relating to industries, public works, and the development of natural resources, through the exchange of individual and group visits.

After the War

IN AN effort to provide for an orderly transition from wartime to peacetime production, a group of outstanding industrialists has formed what is known as the Committee for Economic Development. Although the movement is completely independent of any private or governmental agency, it has the sanction of the Federal Government, which has given it offices in the Commerce Building in Washington and made available to it the facilities and statistical data of the Department of Commerce.

The primary aim of the committee is to induce every one of the nation's manufacturing concerns to make an intelligent study of its probable position in the postwar era and to formulate plans for future operations accordingly. To assist them in doing this, the committee has published a booklet containing pertinent information regarding the demands for various types of goods and services that may be expected at that time. Large concerns already have given much thought to their postwar status, but smaller ones probably have done little along this line. To stimulate them into action, it is proposed to organize a committee for economic development in every community in the country with a population of 10,000 or more. At the beginning of September, chairmen of such committees had been named in 705 cities, leaving between 500 and 800 yet to be chosen. Through such committees it is expected to reach most of the 2,000,000 small businessmen for the primary purpose of helping him to solve the unemployment problem that is bound to arise when shooting stops.

Our Future Oil

ONCE again we are being told that our supply of petroleum is diminishing at an alarming rate. Similar forebodings have arisen at intervals in the past, only to be followed by discoveries of huge additional deposits, such as Kettleman Hills, California, the Illinois fields, and those in East Texas and the Houston area. Previous warnings of impending shortages were sounded without reckoning with the science of geophysics. That amazing development helped geologists to locate oil with much greater certainty than before and reduced the gamble of wildcat drilling immeasurably. Then too, advances in technology and equipment manufacturing enabled drillers to probe much deeper than was previously possible.

This time, however, the predictions that we will feel the pinch of depletion within the next ten or fifteen years if the current rate of consumption continues seem to be well-grounded. The longer the war lasts, the faster our known resources will dwindle. Fortunately, there is something we can do about it, and that is why Secretary Ickes, of the Department of the Interior, and other national leaders are urging that action be taken before it is too late.

The nation's oil-shale deposits, principally in the West, contain enough recoverable oil to last us 65 years, while our coal resources are such as to provide us with 1,500,000,000 gallons of synthetic gasoline annually and still supply all the grates of the nation with coal. Oil has been produced abroad from both shale and coal, and the U. S. Bureau of Mines has done considerable research work along that line in this country. What is needed now is that the methods developed in the laboratory be placed on a commercially practicable scale, and Senator Joseph C. O'Mahoney has already introduced a bill in Congress to that end. Very likely steps will be taken to assure us an adequate supply from those sources before the wells run dry.

"Double-Barrelled" Spray Gun

FIBROUS materials and adhesives of various kinds for purposes of thermal insulation, sound absorption, and condensation control are applied by what is known as the Sprayo-Flake process that makes use of what might be called a "double-barreled" spray gun. The latter consists essentially of a 2½-inch aluminum tube through which the material is projected in a dry state, and of a series of five nozzles, superimposed upon and encircling the discharge end of the tube, through which the adhesive is forced. The nozzles are set so that the liquid issues in a conical spray with the apex a short distance from the head of the tube. By this arrangement it is possible in one operation to prime the surface to be insulated, to coat the fibers with the adhesive, and to apply them.

The dry material used depends upon the nature of the service and includes fire-resistant cellulose and mineral fibers. It is fed automatically from an electrically controlled hopper, the flow being started and stopped by a switch on the gun. The adhesive is contained in a tank under approximately 50 pounds pressure, and a small single-stage compressor with a capacity of 12 cfm. at 80 pounds pressure supplies the air for application and atomization. Valves on the gun permit the operator to regulate the flow of the fluid and the air.

According to the manufacturer, any desired thickness of insulating blanket can be built up in this way on wood, masonry, concrete, metal, plaster, or other surfaces. The cellular mat remains flexible indefinitely and is of sufficient resiliency to remain unaffected under normal expansion and contraction of a structure due to temperature changes. Laboratory tests have shown that it will not slip, sag, or fall when applied to surfaces exposed to extremely low temperatures or to heat up to 300°F. Other advantages claimed for it are that it is odorless and vermin-proof. The equipment is leased by the Sprayo-Flake Company to applicators capable of handling the work, and five different coatings are available in a variety of textures and colors.

THREE OPERATIONS IN ONE

This air gun is designed to spray both a liquid adhesive and a fibrous material, the former priming the surface to be insulated and coating the fibers at one and the same time. It is shown here applying a thick blanket of Sprayo-Flake to the underside of a corrugated metal roof for thermal insulation and condensation control.

Telephone Cables Tested with Compressed Air

IN testing telephone cables, it is generally the practice to introduce nitrogen gas that is stored in flasks for convenient application. However, the increasing demand for compressed gases in war-production plants has resulted in a shortage of containers, and telephone companies have had to devise some other means of doing this work. The answer to their problem is compressed air, which is furnished on the spot and at the desired pressure by a small electrically driven unit of the diaphragm type. The compressor is packed in a strong plywood case ready for haulage by truck to any point where its services might be required. Accessory equipment includes a length of hose wound on a reel at the end of the machine and two glass cartridges that serve as moisture separators.

The air used for testing must be free of oil and water, and this is assured by a chemical that changes color to indicate when maximum absorption has been reached. This explains why it is put in transparent cartridges. When one of the latter has become fully saturated in the course of operations, the air is caused to flow though the spare simply by closing a valve. The exhausted unit is reactivated by heating it in an oven. As a safety feature, the compressor is provided with a relief valve that functions when the pressure reaches 15 pounds per square inch. This is necessary to avoid damaging a cable by building up disruptive pressures.

Photo, U. S. Army Signal Corps.

TAKING NO CHANCES

The portable low-pressure chamber shown here is part of the equipment of the U. S. Air Force Provisional Medical School somewhere in England and is used to test the physical fitness of American air crews. The men are under observation all the while they are in the chamber, where they undergo conditions similar to those experienced at varying altitudes in actual flight.

New Plating Process

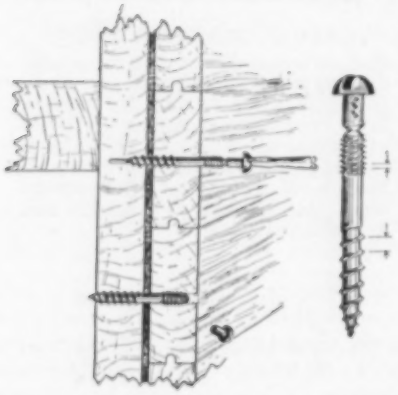
ACCORDING to a recent announcement, it is possible to plate plastics, glass, or any nonconductor with metal. The process permits plating not only flat and simple round surfaces but also convex and concave ones, convolutions, corners, and recesses with any of the customary plating metals. Aside from the conservation of strategic metals, the departure in practice effects a considerable reduction in weight of given parts. Further claims made are that the bond is a permanent one and that the plating does not crack, chip, or peel off even after long and hard service. The work is being done by the Precision Paper Tube Company.

Industrial Notes

Appropriately, the 26 reinforced-concrete barges that are being built for the U.S. Maritime Commission are being given the names of minerals. The first of the vessels were christened *Agate, Chromite, Flint,* and *Granite.*

Rhenium, a rare silver-colored metal that is heavier than lead, is contained in ore produced in the western states and has been found in the flue dust of American steel mills. The metal has several secret war uses.

Something different in steel screws has been introduced by Wilson Manufacturing Corporation under the name of No-Slip. As the drawing shows, it has two sets of threads: a coarse one near the point and a finer one close to the head, the former engaging one of the two boards to be held together and the latter the other. It is claimed that the



difference in pitch draws the planks together and locks them. Another feature is the head which is designed to be snapped off either by the screwdriver or by pliers. Two sizes are at present available: 1¾ and 2⅝ inches long with the heads, or 1½ and 2¼ inches without.

A new method of detecting surface flaws and cracks in nonferrous metals that is said to be simpler and quicker than those in common use has been reported in England. By it, forgings or castings undergoing testing are heated in a special liquid, drained, and then suspended for a few seconds in the vapor that arises from the bath. Upon cooling, fluorescent crystals form along any flaw or crack in the metal. Under ultraviolet light the defects are revealed by iridescent green lines.

The Ashcroft Gauge Division of Manning, Maxwell & Moore, Inc., has announced a new type of pulsation dampener for pressure mediums such as air, water, oil, or steam. It is a small, compact throttling device for use with gauges that are subjected to severe pressure pulsations and rapid fluctuations such as in reciprocating pumps. It is designed for pressures up to 5000 pounds per square inch and consists of a small monel plunger that oscillates freely in one of five cylindrical holes of different sizes in a bushing. The clearance between the plunger and the hole is just sufficient to give the proper throttling action for a specific condition. All but the hole in service are sealed by a disk. The free movement of the plunger makes the dampener self-cleaning. Type 1106, as it is designated, is said to eliminate excessive or harmful pointer vibration, to lessen wear on the gauge movement, to keep the instrument in calibration, and to facilitate reading the true mean pressure.

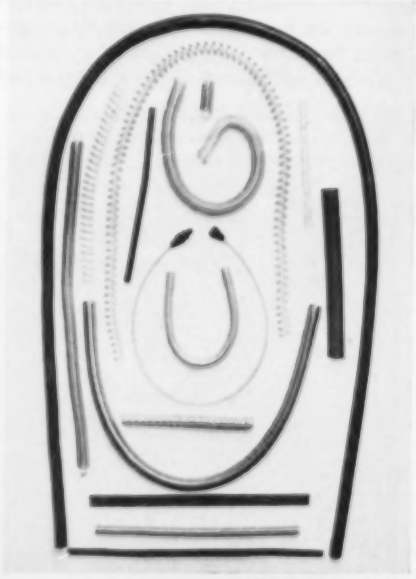
Silco is the trade name of a new vitreous, inorganic coating that is serving as a substitute for plating materials. It is applied by spraying, dried at 200°F., and baked at 350° in a convection-type oven or by infrared lamps. At present it is produced in black, Army drab, and Navy gray, with a dull finish that may be buffed to a beautiful eggshell gloss. The coatings range in thickness from 0.0001 to 0.0002 inch and are said to resist acids, mild alkalies, rust, corrosion, abrasion, and heat up to 1000°. They are not flexible, but will bend 30° without breaking.

That certain clays are a source of alumina is not news; but that a plant is to be built in the United States to extract that vital mineral from clays is a significant announcement. The deposits to be developed, which have been explored and proved by engineers of the U. S. Bureau of Mines, are located in Oregon and Washington and are said to contain anywhere from 10,000,000 to 40,000,000 tons suitable for treatment by a special method of beneficiation. The Columbia Metals Corporation has received WPB approval for the erection of the plant, which will handle 250 tons of clay daily and consume more than 5,000 kw. of Bonneville Dam power. The estimated cost is $4,000,000.

Motion Pictures Available

HOW the 13.06-mile Continental Divide Tunnel in Colorado is being driven is shown in a motion picture that has been taken for Ingersoll-Rand Company. It is a 16-mm. Kodachrome film with sound track, and is reputed to be one of the first colored motion pictures ever made underground. It is available to technical schools, engineering societies, private concerns, and other interested organizations for use without charge. The projection time is about 40 minutes. The company also has three films designed to train operators of rock drills how to set up and operate stopers, hand-cranked drifters, and power-feed drifters. These are 16-mm. black-and-white films with sound, and run from 10 to 15 minutes each. Any of these pictures are available without charge upon application to the company's general office at 11 Broadway, New York 4, N.Y., or any of its engineering service branches in the United States. To insure obtaining the films when they are wanted, applicants are asked to request them considerably in advance of the date they are to be shown.

A service of an unusual nature primarily for the research worker in industry is being offered by McLarty Business Films of Buffalo, N. Y. The firm specializes in taking motion pictures that will enable engineers and laboratory men to study operations, motions, and phenomena that the eye cannot follow. The camera used is of a special type and exposes 3,000 pictures a second when running at its maximum speed of nearly a mile a minute. When projected on the screen, the 16-mm. film travels 250 times slower. It can be reversed and also stopped for close observation. The concern is prepared to do the work in any part of the United States and Canada.



Photo, Brosco, Inc.

THEY'RE FLEXIBLE

Here are a variety of plastic specialty products of recent introduction. Included among them are coils, some so limp that knots can be tied in them; springs that can be stressed and released repeatly, but not kept extended, without appreciable loss of their elastic property; and tubing either in extruded or coiled form. The latter type, covered with vinylite, for example, is said to lend itself to the making of speaking tubes because of its unusual sound-carrying properties.

In war or peace
B.F.Goodrich
FIRST IN RUBBER

First and only grommet-type wire V belt

For use where others have failed and where V belts have never before been possible

Transmits more h. p., has greater strength, no stretch, needs less maintenance

THIS new V belt is made with the grommet principle, a B. F. Goodrich development that gives greater strength, and transmits more horsepower for a given size of belt.

Ordinary wire V belts are made by winding a continuous wire around a drum, then cutting into narrow sections to form the individual belts. Thus in ordinary belts there is a point on each side where the wire is close to the edge. The B. F. Goodrich grommet is made by forming wire cable into a loop, then winding it spirally on itself up to the needed size. It's endless; in the belt it is always the same distance from the edge (wires will never be exposed by slight wear); it has less stretch than small individual cables, more strength for a given amount of wire. Thus it transmits more horsepower for a belt of given size.

The wire grommet, spirally wound in one direction, is covered by cord spirally wound in the other direction. Thus each grommet is balanced—and each belt is balanced.

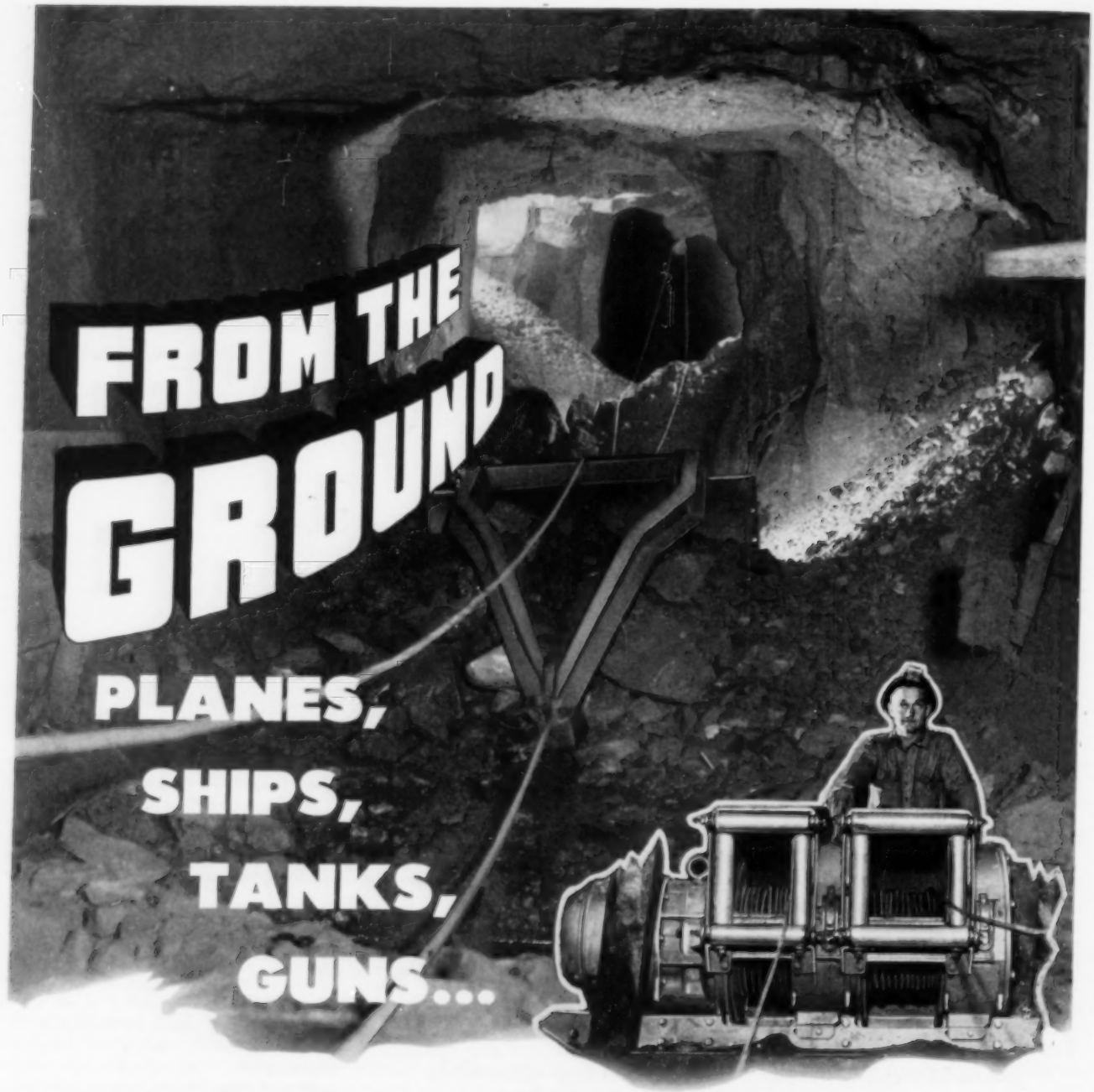
Strongest V belt ever made

This new principle makes the strongest V belt ever produced in proportion to size and weight. The well-known V belt advantages of efficient power transmission, low maintenance, long trouble-free life, quiet and clean drives, less weight are now available for many drives which have always had to put up with heavier, costlier methods.

If you have drives on which other belts have failed — or drives on which lack of strength has made former V belts impractical — write B. F. Goodrich. Our belt specialists will help you engineer this revolutionary new belt to your drives to give you greater power efficiency, and save you money, trouble and production time. *The B. F. Goodrich Co., Industrial Products Division, Akron, O.*

B.F. Goodrich

RUBBER *and* SYNTHETIC *products*



Tremendous tonnages of metallic and non-metallic ores must be mined daily to provide the raw materials needed to build the hundreds of weapons of war.

Thousands of mines operating day and night — to make this production possible — depend on *slusher hoists* for the speedy and economical handling of materials, whether it be production, development, filling or transfer work.

Ingersoll-Rand Slusher Hoists are in active service with the producers of iron, copper, nickel, lead, zinc, aluminum, silver, tungsten, and many other important metallic and non-metallic ores required to win the war.

At a speed of 250 feet per minute, 1½ tons of tungsten-molybdenum ore are scraped a distance of about 110 feet to a short slide. This outstanding performance is commonplace for the Size 50NM-4D Tugger Hoist and the 66" hoe-type scraper. This application is multiplying manpower by eliminating numerous chutes, chute loading and the tie-ups connected with that type of operation.

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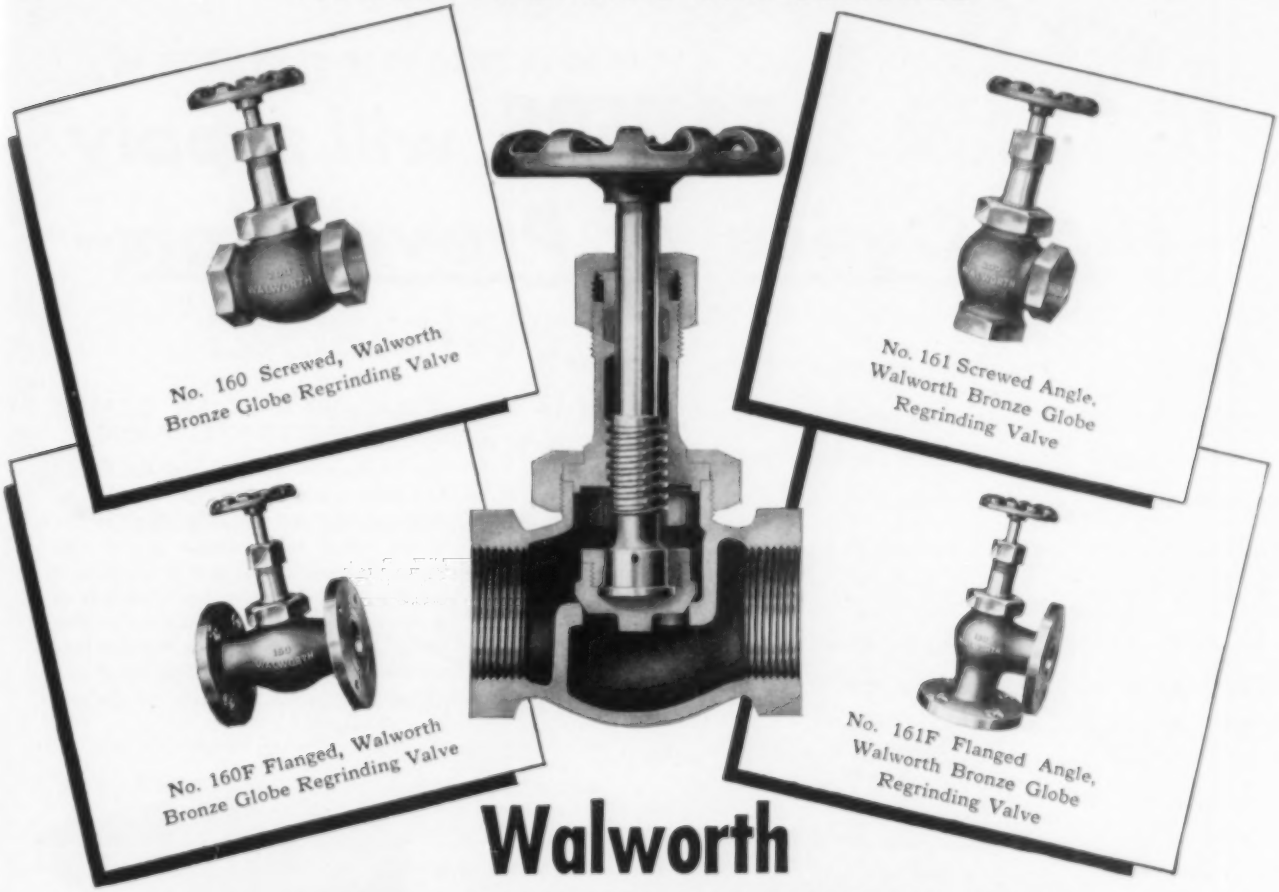
COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

FIT THE VALVE TO THE SERVICE


No. 160 Screwed, Walworth Bronze Globe Regrinding Valve
No. 161 Screwed Angle, Walworth Bronze Globe Regrinding Valve
No. 160F Flanged, Walworth Bronze Globe Regrinding Valve
No. 161F Flanged Angle, Walworth Bronze Globe Regrinding Valve

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BRONZE REGRINDING VALVES

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choose the type that fits your service

When you need a Bronze Valve select from Walworth's *complete line* the one that precisely fits your service. Take this line of regrinding valves, for example. These valves are made both in Globe and Angle types with either screwed or flanged ends. Union Bonnets give added strength. All valves have bronze discs and full-way seats. Moreover, well proportioned stuffing boxes and glands assure leak-proof operation. These valves can be repacked under pressure when fully opened, and should the seats and discs become worn, they can be reground.

Each Walworth Valve has distinctive features of design and construction. You can save time, material, and much trouble-some maintenance when you "fit the valve to the service."

To help you "fit the valve to the service," you'll find pertinent information on Walworth's complete line of valves, fittings, pipe, and pipe wrenches in the New Walworth Catalog 42. Included are 78 pages of practical engineering data that simplify valve selection and make piping layouts easier. Write, on business stationery, for your free copy. Address: Walworth Company, 60 E. 42nd St., New York 17, N. Y., Department 017.

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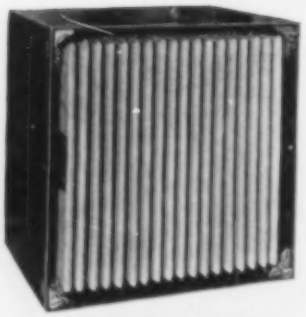
AAF AIR CLEANERS will supply that Ounce of Prevention—

It's far less costly to prevent a breakdown than to correct it after it has happened. The small investment entailed in equipping your power equipment with the *best* air cleaners certainly pays dividends as users of AAF filters throughout the nation will testify. Consider the *best—first* when specifying air cleaners. Free bulletins describing the Cycoil Oil Bath Cleaner with 4-way cleaning, and other types of AAF filters for every engine and compressor requirement will be sent on request.

CYCOIL OIL BATH AIR CLEANER PROVIDES 4-WAY CLEANING

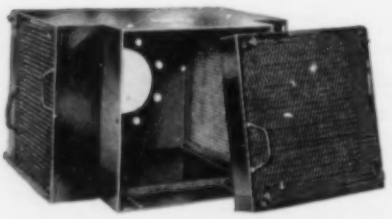
The fundamental advantage of the Cycoil Oil Bath cleaner is that the incoming air stream picks up an unusually large quantity of oil which is thoroughly mixed with the air (causing a scrubbing or precleaning action), and then thrown out by centrifugal action before the air stream enters the filter cell. This results in reducing the dust load on the filter cell and insuring continued self-cleaning action. Ask for Bulletin No. 130-D.

AMERICAN AIR FILTER COMPANY, INC.
Incorporated
402 Central Avenue, Louisville, Ky.
In Canada: Darling Bros., Ltd., Montreal, P. Q.



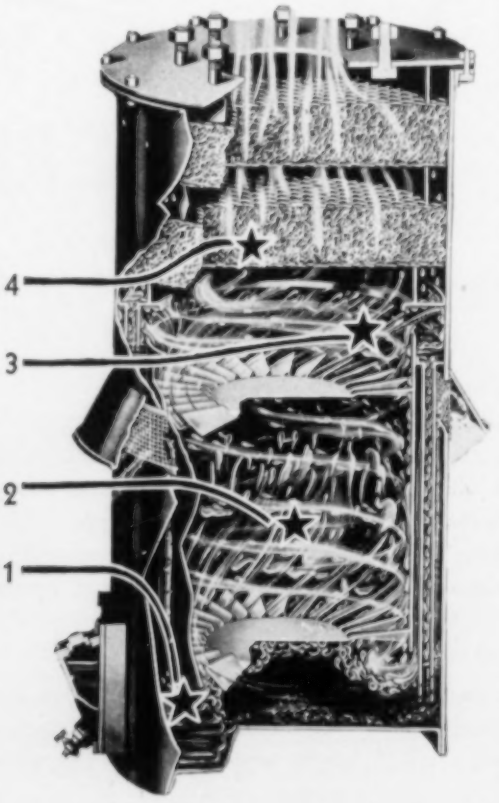
TYPE FC-H FILTER

Filter element is made from a special wool felt into a glove which fits over a spacer frame. Easily removable for dry cleaning. Recommended where heavy concentrations of dry dust are present. Bulletin No. 120-D.



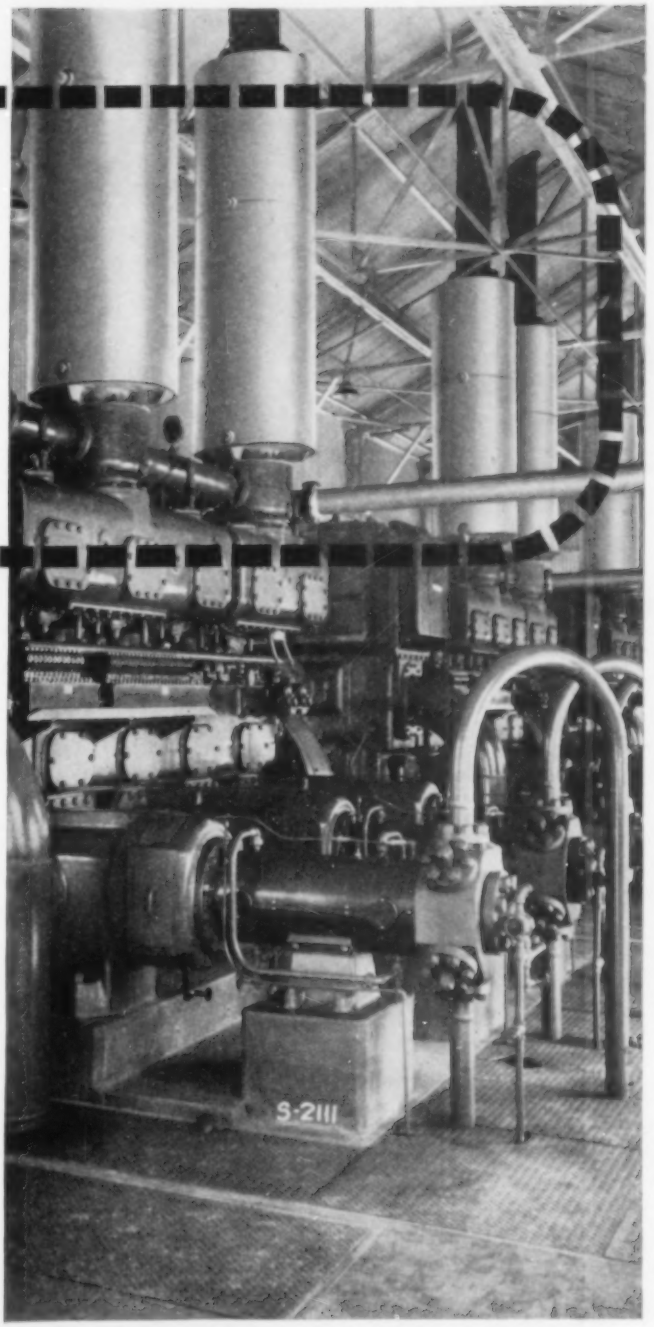
TYPE OCH FILTER

Complete assembly consisting of washable viscous impingement type filters. 1, 2, 3, or more cells are used, depending upon size of cleaning job. Ask for Bulletin No. 120-D.



AMERICAN AIR FILTERS
for Engine and Compressor Protection

so that men can hear themselves think . . .



In providing effective silencing for Diesel exhaust, Maxim Silencers contribute largely to the efficiency of the man-hours within a plant. Excessive noise acts as a specific strain on nervous systems, but beyond this, in a noisy plant, routine and necessary instructions may be incorrectly heard or not heard at all. Then, of course, there are always those living near the plant, war workers trying to sleep during the day, near neighbors carrying on their daily routine . . . all of whom benefit when Maxim Silencers do their job day and night.

MAXIM WASTE HEAT UNITS SAVE FUEL

Maxim Waste Heat Units utilize waste exhaust heat to produce steam or hot water for use in heating or processing operations. These units are compact and efficient and combine waste heat recovery with effective silencing of exhaust noise and, where indicated, with the positive Maxim Spark Arrestor feature.

Widely used today in the marine field where fuel saving is of prime importance, Maxim Waste Heat Units are also finding broad applications in the industrial field. Descriptive Bulletins WH-100, WH-102, WH-103 on request. The Maxim Silencer Co., 85 Homestead Ave., Hartford, Conn.

MAXIM

"We'll take the RISKS"

"...if you'll send us the guns!"

Our boys will gladly risk their lives for Freedom. All they ask of us back home is that we send them the guns, shells and equipment—and send it *fast*. They'll do the rest. So let's keep production zooming along at top-speed. One way to help speed production is to use Garlock Packings, Gaskets and Oil Seals—they give long, dependable service and help you avoid frequent shut-downs.

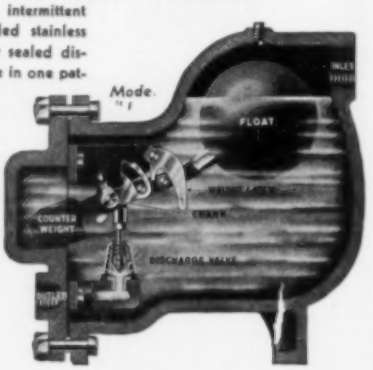
THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK
Manufacturers of GARLOCK Packings, Gaskets and KLOZURE Oil Seals

In Canada: The Garlock Packing Company of Canada Limited, Montreal, Que.

GARLOCK

Users Say: "NICHOLSON COMPRESSED AIR TRAPS INCREASE EFFICIENCY OF PNEUMATIC TOOLS BY PROPERLY DRAINING AIR TANKS, RECEIVERS, AFTER COOLERS, ETC."

The Nicholson "JR" Trap is specially designed and constructed to provide long, trouble-free service under continuous operation. Large capacity . . . for pressures up to 200 lbs. . . . intermittent discharge . . . welded stainless steel float . . . water sealed discharge valve . . . made in one pattern size only with either ½", ¾" or 1" inlet and ½" outlet.



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THERMOSTATIC ▼ PISTON AND WEIGHT-OPERATED STEAM GASOLINE AND COMPRESSED AIR TRAPS ▼ ▼ ▼

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for extremely heavy construction and erection work.

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for average work, which includes most of the service in industry and construction.

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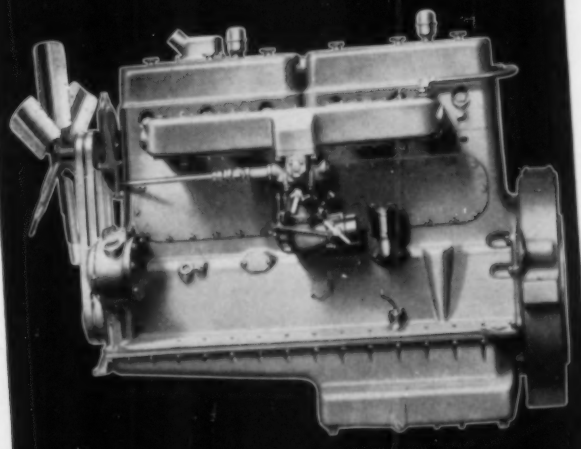
Iron ore is hauled right from the mine by Walter Tractor Trucks, with 35-ton side dump ore trailers, powered with 300-hp. Model 6-WAK Waukesha Engines, 6½" bore x 6¼" stroke, 1197 cu. in. displacement.

WAUKESHA ENGINES.....give Walter Ore Tractors extra power



● Snyder Mining Company, Chisholm, Minn., has an off-the-highway hauling job that's tough—hauling iron ore right out of the mine.

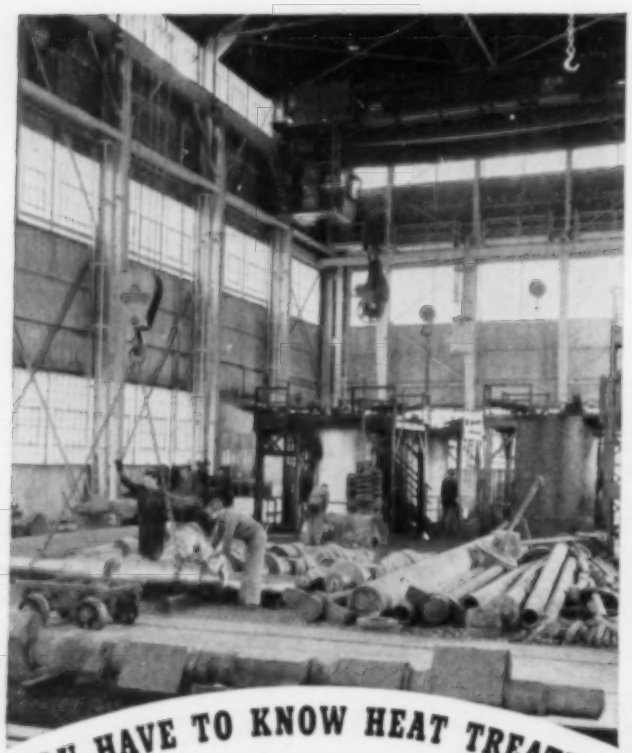
Walter Tractors are doing it . . . and doing it well. All four of these new ones have Waukesha Engines.

These big, butane-burning Model 6-WAK Waukesha Engines are designed and engineered to deliver greater power per cubic inch displacement. Or, as the mining company's truck drivers call it—"plenty of power and lots of zip" according to Mr. Tancig, general mechanical superintendent, who also says, "the truck drivers like to drive these large units." *Get Bulletin 1138.*

WAUKESHA MOTOR COMPANY, WAUKESHA, WIS.
NEW YORK • TULSA • LOS ANGELES

MORE POWER FOR VICTORY

WAUKESHA ENGINES



YOU HAVE TO KNOW HEAT TREATING TO KNOW STEEL FORGINGS

• No matter how fine the steel making, or how expert the forgesmithing, a heavy duty steel forging can still come far short of what it should be, if it is not heat treated exactly right. At National Forge heat treatment is conducted in specially designed furnaces—vertical furnaces being used for long pieces and horizontal furnaces for heavy, compact pieces—because National Forge has found that for overall uniformity and avoidance of internal stresses, the furnaces must be suited to the job.

A permanent, chronological record of the entire heat treatment is automatically recorded—assuring positive control and providing the customer with a definite history of how the forging was heat treated. Users of heavy duty steel forgings have learned the importance of expertly controlled heat treatment, which is another convincing reason why they should be National Forged.

NATIONAL FORGE & ORDNANCE CO.

IRVINE, WARREN COUNTY, PENNA.

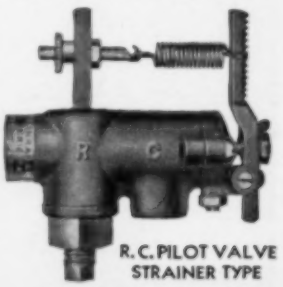
"WE MAKE OUR OWN STEEL"

For Excellence in Production

War Bond Buyers are Guarantors of Victory

R. C. PILOT VALVES FOR POSITIVE CONTROL

R-C Unloader Pilot Valves (plain or strainer type) are standard on many leading compressors . . . installed as replacements on thousands of compressors in all parts of the U. S. A. and overseas. The R-C valve—positive in action—cannot chatter . . . it's always in open or closed position. Adjustment is provided for any unload-to-load range from 3% to 30% of maximum receiver pressure. Install an R-C Unloader Pilot valve—let performance prove its value. Specify air pressure and range of on-and-off operation desired. Write for price and recommendation.



R. C. PILOT VALVE STRAINER TYPE

R. CONRADER CO.

1207 FRENCH STREET - ERIE, PA.

PILOT VALVES for Portable and Stationary Air Compressors provided with Unloaders

WAGNER COMPRESSOR MOTORS

When you need compressor motors to help you carry on essential production, specify WAGNER. 29 sales and service branches, located in principal cities, are ready to help you in selecting the RIGHT Wagner Motor.

WRITE FOR BULLETINS MU-182—MU-183

M43-19

Wagner Electric Corporation

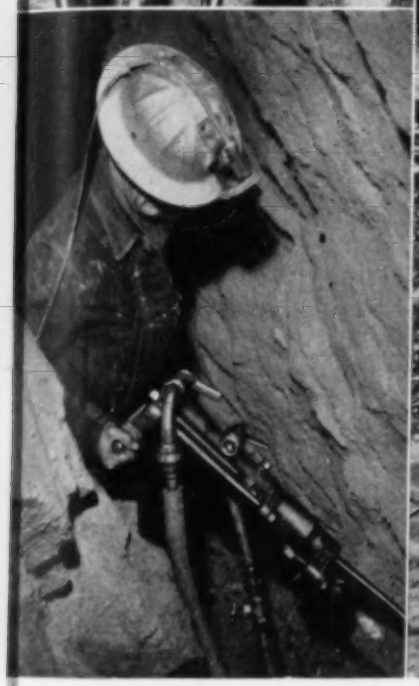
ESTABLISHED 1891

6418 Plymouth Avenue, St. Louis, Mo., U. S. A.

ELECTRICAL AND AUTOMOTIVE PRODUCTS

DRILLING FOR VICTORY

REQUIRES SPEED AND DURABILITY



Top: A DA-35 Power Feed Drifter in a western metal mine.

Bottom: The easy-holding feature of the JB-5 Jackhamer helps this operator mine more ore.

An FM-2 Wagon Drill operated by an IK-315 Mobil-Air compressor working on a new reservoir needed to supply water to an increased war worker population.

INGERSOLL-RAND ROCK DRILLS have the speed and durability required for mining essential metals and for building air bases, strategic highways and hydroelectric projects without which the war cannot be fought successfully.

Ingersoll-Rand Jackhamers with their easy-handling features enable drill runners to produce more feet of hole per shift. I-R Drifters and Stopehamers have broken drilling records in all parts of the country. Our Wagon Drills provide unexcelled flexibility and deep-hole drilling power.

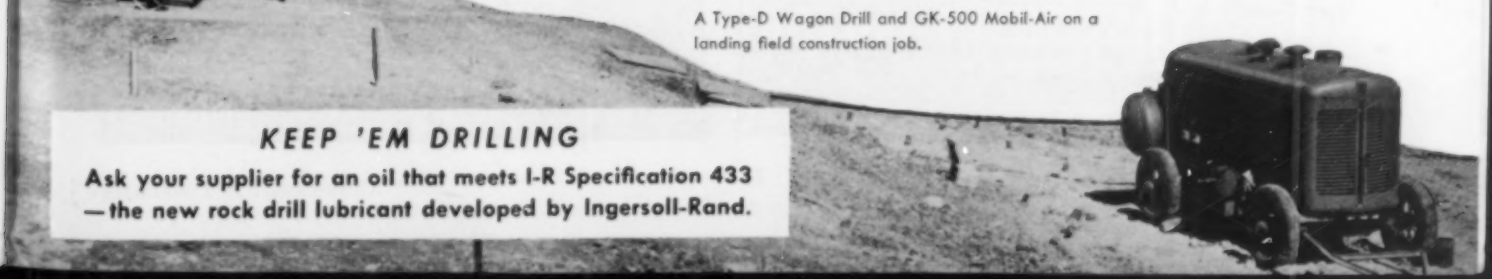
More than 70 years of rock drill designing experience provide the "know how" which enables us to produce the type of machine preferred by those who have real rock drilling problems.

Ingersoll-Rand

11 BROADWAY, NEW YORK, N. Y.

S-32C

A Type-D Wagon Drill and GK-500 Mobil-Air on a landing field construction job.



KEEP 'EM DRILLING

Ask your supplier for an oil that meets I-R Specification 433 —the new rock drill lubricant developed by Ingersoll-Rand.

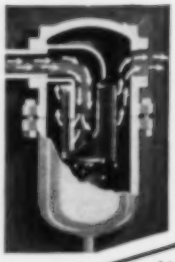
MAKES *Compressed Air* COME CLEAN

THE JOHNSON GAST *2-way* SEPARATOR

WATER, dirt and oil in compressed air lines can be a big source of trouble and expense—causing imperfect results, and deteriorating air hoses and equipment rapidly.

The Johnson-Gast Separator is the simplest way to make your compressed air come clean. It takes out more than 99% of all troublesome foreign elements, because it employs *both* of the accepted principles of separation—expansion and change of direction. The illustration shows its simple, sturdy construction. It can be used with equal efficiency on steam lines also.

When moisture in the air is vaporized by heat generated during compression, the Johnson-Gast Aftercooler is used to condense all vapor so the Separator can remove it. Where every final trace of oil must be removed—as in paint spraying—the Johnson-Gast Oil Absorber is also used.



1. Air first expands, precipitating most of moisture.
2. "Thousand Baffles," labyrinth of wire mesh, changes flow direction — captures remaining water and dirt.

Write for bulletin showing sizes and capacities of the complete Johnson-Gast line of separating devices.

THE JOHNSON CORPORATION
830 Wood Street, Three Rivers, Mich.

JOHNSON-GAST
SEPARATORS • AFTERCOOLERS • OIL ABSORBERS

SNUB THE SLUG

PREVENT THE NOISE

BURGESS SNUBBERS for Quiet Compressor Intakes

Acoustic Division, Burgess Battery Co.
2823-1 W. Roscoe Street, Chicago

CONNECTING RODS *are* L-O-N-G-E-R *in* WISCONSIN HEAVY-DUTY AIR-COOLED ENGINES

The length of rods in Wisconsin Engines is 2½ times the length of the stroke. This extra length is an important factor in reducing vibration to a negligible minimum because *long rods reduce angularity* and this, in turn, reduces piston pressures against the cylinder walls. The shorter the rod, the greater the vibration and wear — so we don't use short rods in Wisconsin heavy-duty air-cooled engines. Another detail that contributes to Wisconsin dependability.

MOST POWER Per POUND

WISCONSIN MOTOR Corporation
MILWAUKEE, WISCONSIN, U. S. A.
World's Largest Builders of Heavy-Duty Air-Cooled Engines

NO OTHER COUPLING *gives all its operating advantages*

WALDRON GEAR TYPE COUPLING

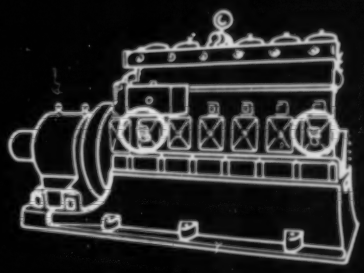
1. Positive seal protects against dust and oil leakage.
2. Hubs and Cover Sleeves are Heat Treated Forgings.
3. All metal contact parts constantly lubricated.
4. Longer lining up surface of hubs.
5. Cover sleeves function as single rigid unit.

Our Catalog 56 gives tables of Service Factors, Sizes and Ratings. Write for copy.

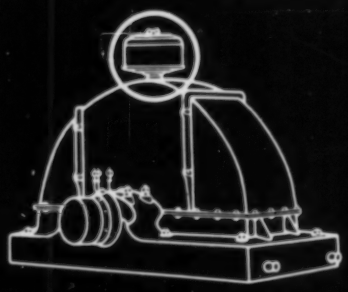
Although war work needs receive our first attention, we invite your inquiry.

JOHN WALDRON CORP.
NEW BRUNSWICK, N. J.

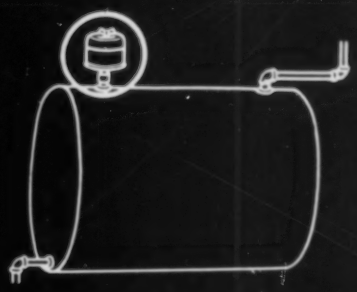
GIVE 'EM AIR..clean air!



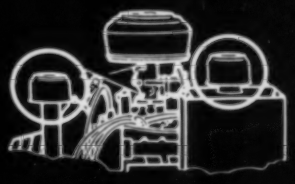
TWO AIR-MAZE BREATHER-FILTERS INSTALLED ON CRANKCASE OF 9 CYLINDER GAS ENGINE



TYPICAL APPLICATION OF AIR-MAZE GEAR CASE BREATHER

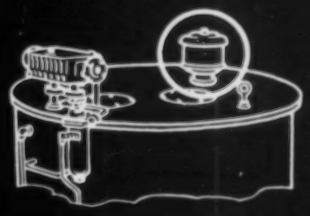


LIQUID STORAGE TANK, PROTECTED BY AIR-MAZE BREATHER AND FLAME ARRESTER



AIR-MAZE BREATHERS VENT CRANKCASE OF BOTH ENGINE AND COMPRESSOR IN THIS INSTALLATION

VALVE HOUSINGS ON ENGINE ARE VENTED BY TWO AIR-MAZE BREATHER-FILTERS



HYDRAULIC PRESS, EQUIPPED WITH LARGE AIR-MAZE OIL-BATH TYPE BREATHER-FILTER

One reason for covering up important machinery and for storing liquids in closed tanks is to keep them clean. Open vents in these enclosures invite dirt and contamination.

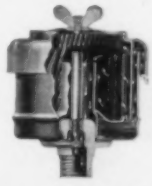
Vents protected by Air-Maze breather filters, however, let air pass, but stop dirt. Used on crankcases of engines and compressors, gear cases, hydraulic equipment and machinery housing, they help keep lubricants clean and prevent needless wear. On liquid storage tanks they capture undesirable substances, and act as efficient spark and flame arresters. (Air-Maze breather filters are approved by Factory Mutual Laboratories as flame arrestors for tank vents.)

Both oil-wetted and oil-bath types are available in many sizes and designs. Air-Maze representatives will gladly assist you in specifying the correct size and type for your needs. Nearly 20 years of experience in solving air-venting problems are at your disposal without obligation.

TYPICAL AIR-MAZE BREATHER FILTERS

Drip pan collects condensed oil vapors in this model.

Standard model commonly used on automotive crankcase breather pipes.



Cutaway view of oil bath type breather, used where dust conditions are severe.

Oil-bath type for use on oil-fill pipe. Oil added to crankcase by lifting top of breather.

AIR-MAZE CORPORATION • *Engineers and Manufacturers* • **CLEVELAND 5, OHIO**

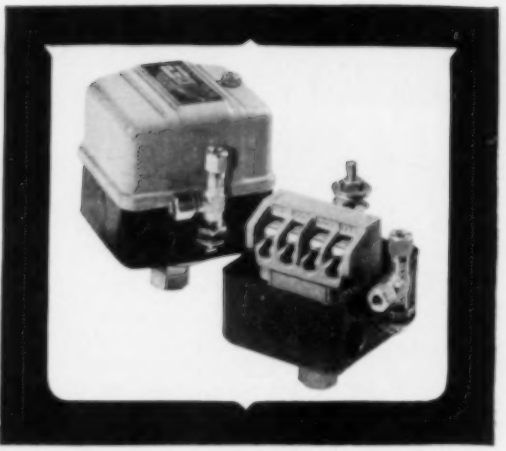
AIR-MAZE

SPECIALISTS IN AIR FILTRATION

A NEW STANDARD

CLASS 9213 TYPE AH3 PRESSURE SWITCH

For the garage-type air compressor, ratings up to 1½ H. P. 110V, 2 H. P. 220V single phase, 3 H. P. 220V polyphase and 1 H. P. 550V single and polyphase, use the 9213 AH3. The pressure limit is 200 lbs., adjustable range and differential. Direct connection to release valve without fittings. Priced right.



SWITCH—PROTECT—REGULATE . . . DO IT ALL WITH SQUARE D

SQUARE D COMPANY • REGULATOR DIVISION • DETROIT

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408 pages, 80 illustrations. Flexible, Morocco binding, gold-edged.

Compressed Air Data

A Handbook on Pneumatic Engineering and Related Subjects

by F. W. O'Neil

Member A.S.M.E., A.I.M.E., American Mining Congress, Mining and Metallurgical Society.

125,000 COPIES IN USE

This 408-page book on the theory and practice of compressed air engineering has been entirely rewritten, rearranged, and enlarged to meet today's needs of industry.

You cannot afford to be without a copy. You will find yourself referring to it daily. It has long been known as the "Bible" of the industry. It covers the subjects in which every owner and user of pneumatic equipment is interested. Price $3.00

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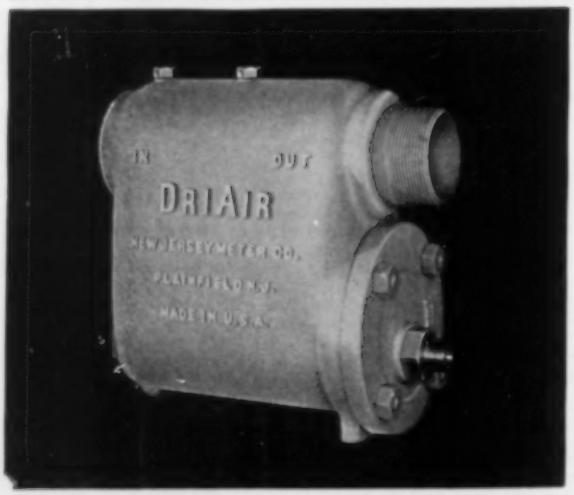
GREATER PNEUMATIC EFFICIENCY



DriAir may be suspended from overhead piping without any other support.

A typical installation showing DriAir standing on the floor next to the wall.

WHEN EQUIPMENT IS PROTECTED BY

DRIAIR

A COMPLETE SELF-CONTAINED UNIT

● DriAir separates and automatically ejects the condensed water and oil from compressed air lines, collects pipe scale and rust, delivers clean dry air to tools and other pneumatic equipment. This promotes better lubrication, reduces wear, increases life of tools and produces greater output. All internal parts are made of bronze or copper—resistant to corrosion and practically permanent.

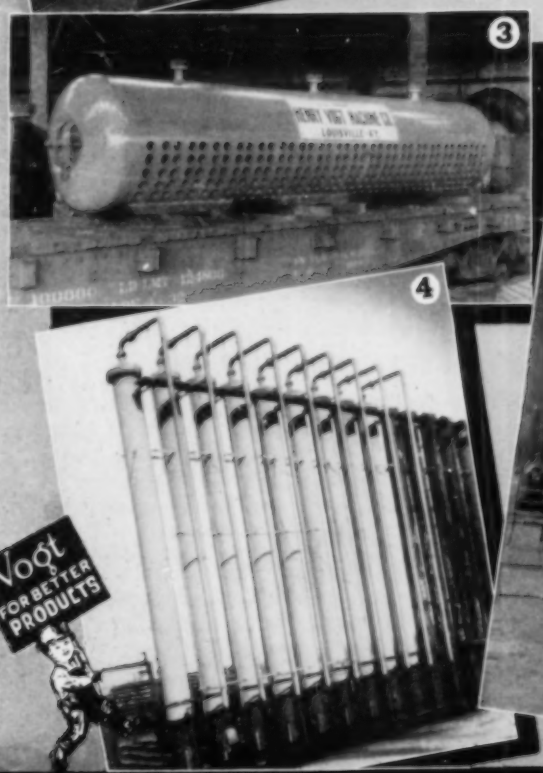
Write for Bulletin DA which fully describes the construction and operation of the DriAir.

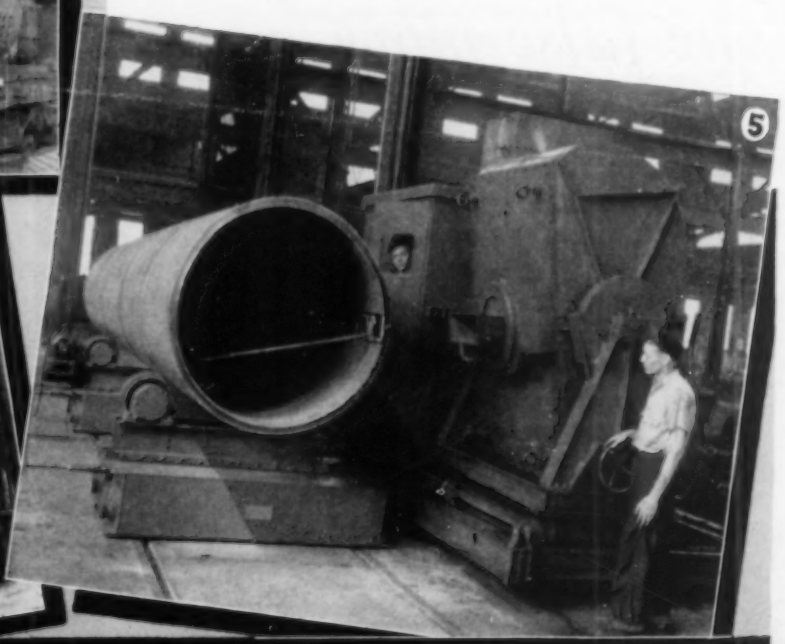
SEPARATES • COLLECTS • DELIVERS

NEW JERSEY METER COMPANY
PLAINFIELD, NEW JERSEY

A.P.I.—A.S.M.E. and A.S.M.E. CODES • CARBON STEEL AND SPECIAL STEEL

WELDED PRODUCTS *by* Vogt





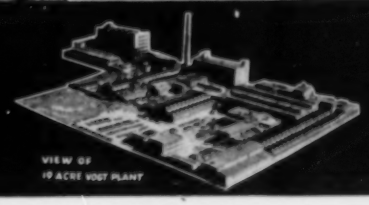
1 - 4′—0″ dia. x 7′—6″ dia. x 82′—5″ high Stabilizer Tower for a Texas Refinery. Fabricated to A.P.I.-A.S.M.E. Code, stress relieved and X-rayed. 250# working pressure.

2 - Heat Exchangers, for an Eastern Refinery, on the testing floor. Units have fusion welded Monel Metal shells and were built to customer's specifications.

3 - 48″ dia. x 22′—6″ long mud drum for a Vogt Water Tube Boiler designed to operate at 450# S.W.P. Fusion welded to A.S.M.E. Boiler Code.

4 - Battery of Absorption Columns in a Western Refinery. Units are 33″ dia. x 41′—0″ high and were stress relieved after welding.

5 - 400 KV Industrial X-ray unit in our plate welding department. Exographs of welded seams can be quickly made because of the special motor operated rolls and traveling carriages which are adjustable to vessels of any size.



HENRY VOGT MACHINE CO.

Incorporated

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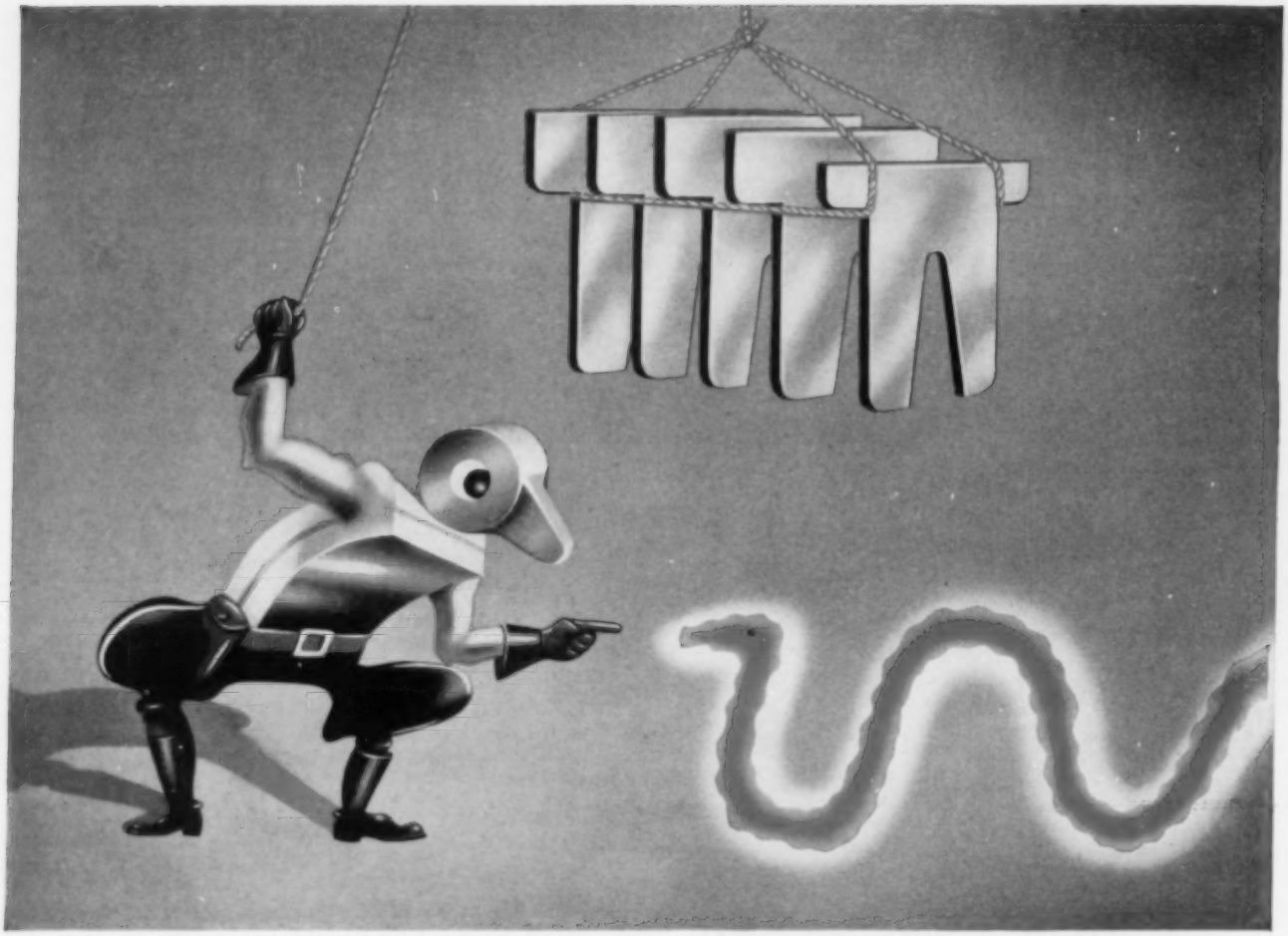
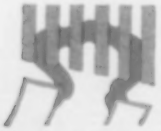
BRANCH OFFICES: NEW YORK · PHILADELPHIA · CLEVELAND · CHICAGO · DALLAS

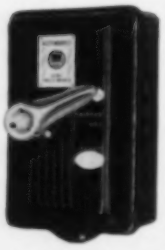


"one false move and you're Dead!"

THIS IS THE BRAIN that tells whether an overload is dangerous or not. It's Westinghouse Bi-metal. Two different metals which react differently under heat are bonded together. Dangerous overloads cause this Bi-metal to bend, tripping the interrupting mechanism, opening the circuit.



THIS IS THE BRAWN that quenches the arc. Made up of parallel metal plates in the form of a grid, it draws the arc into the chamber, divides it into segments and smothers it between the plates . . . it all happens in the space of half a cycle!



Current that gets out of hand and threatens equipment or power circuits gets short shrift when the circuit is protected by Westinghouse "De-ion" Circuit Breakers.

With uncanny accuracy, this "De-ion" protective device outguesses the current, beats dangerous disturbances to the punch. Momentary, harmless overloads are passed without interruption; but when the circuit is actually threatened, the sensitive Bi-metal element goes into action, *quick!* The circuit's broken, the arc quenched, in the space of a blink of an eye.

It protects itself, too. The fast action minimizes arc effects, lengthens contact life. Its factory-set calibration is not disturbed. And, when the interruption has been corrected, a simple flip of the indicating handle restores service in seconds. No time lost locating a busy maintenance man; no parts to repair or replace.

Protect equipment and electrical circuits with Westinghouse "De-ion" Circuit Breakers. Ratings to 600 amperes; enclosures for any type of service. Call Westinghouse today. Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N.

J-21267

WESTINGHOUSE

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

"DE-ION" CIRCUIT BREAKERS

After ★PEARL HARBOR

MOBIL-AIR
Compressors
on their way

Ingersoll-Rand
MOBIL-AIR
AIR POWER

No time was lost in repairing the damage done to our fleet and to our vital naval and air bases at Pearl Harbor . . . and in making sure that it could not happen again.

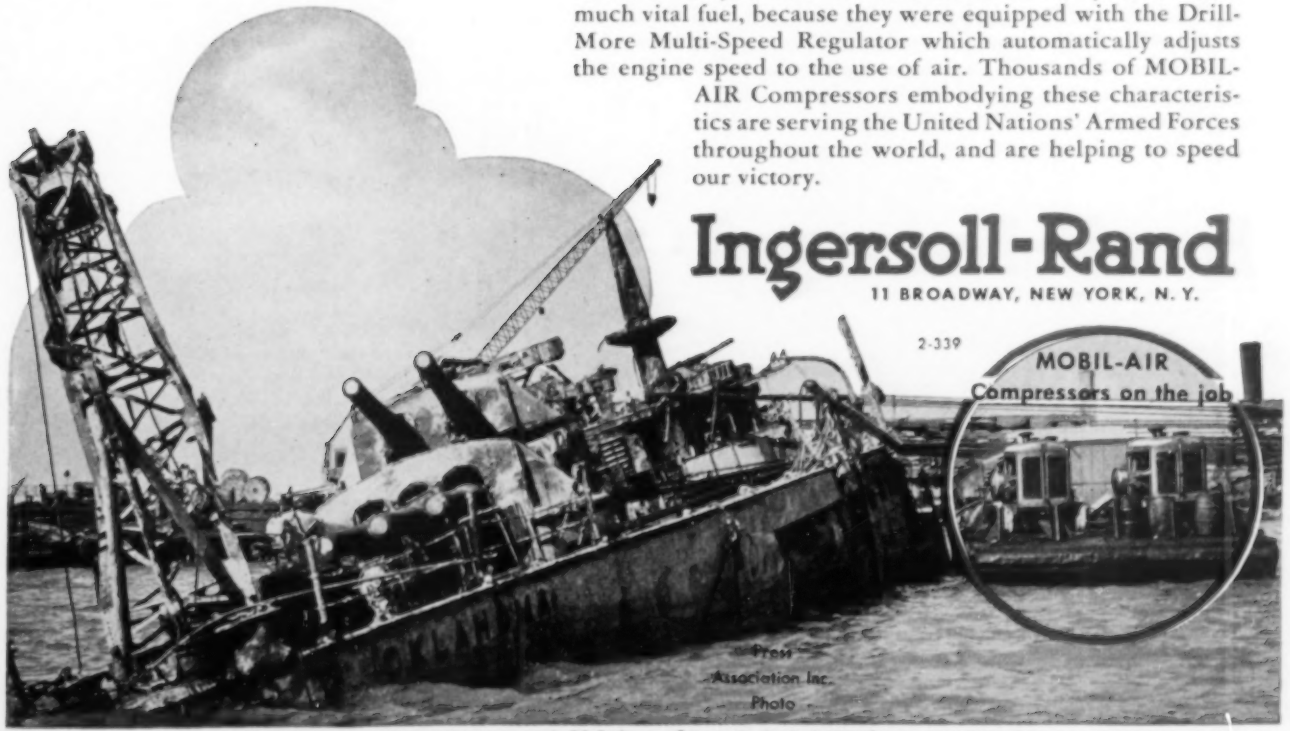
Compressed air power was needed—more than was available—to operate the rock drills, air tools, divers' equipment, and salvage pontoons. So Ingersoll-Rand received emergency orders for substantial shipments of its largest portable air compressors and the air tools used with them.

Our workmen, spirited by the Japanese attack, "turned on more heat." On the last day of that eventful year, a shipment pulled out of our factory, routed straight for Pearl Harbor. The photograph shows two of the K-500 MOBIL-AIR Compressors helping to prepare the battleship U. S. S. Oklahoma for raising and repair.

We knew that these compressors would see hard service, but Ingersoll-Rand MOBIL-AIR (portable) Compressors are built for just that. We also knew that they would save much vital fuel, because they were equipped with the Drill-More Multi-Speed Regulator which automatically adjusts the engine speed to the use of air. Thousands of MOBIL-AIR Compressors embodying these characteristics are serving the United Nations' Armed Forces throughout the world, and are helping to speed our victory.

Ingersoll-Rand

11 BROADWAY, NEW YORK, N. Y.



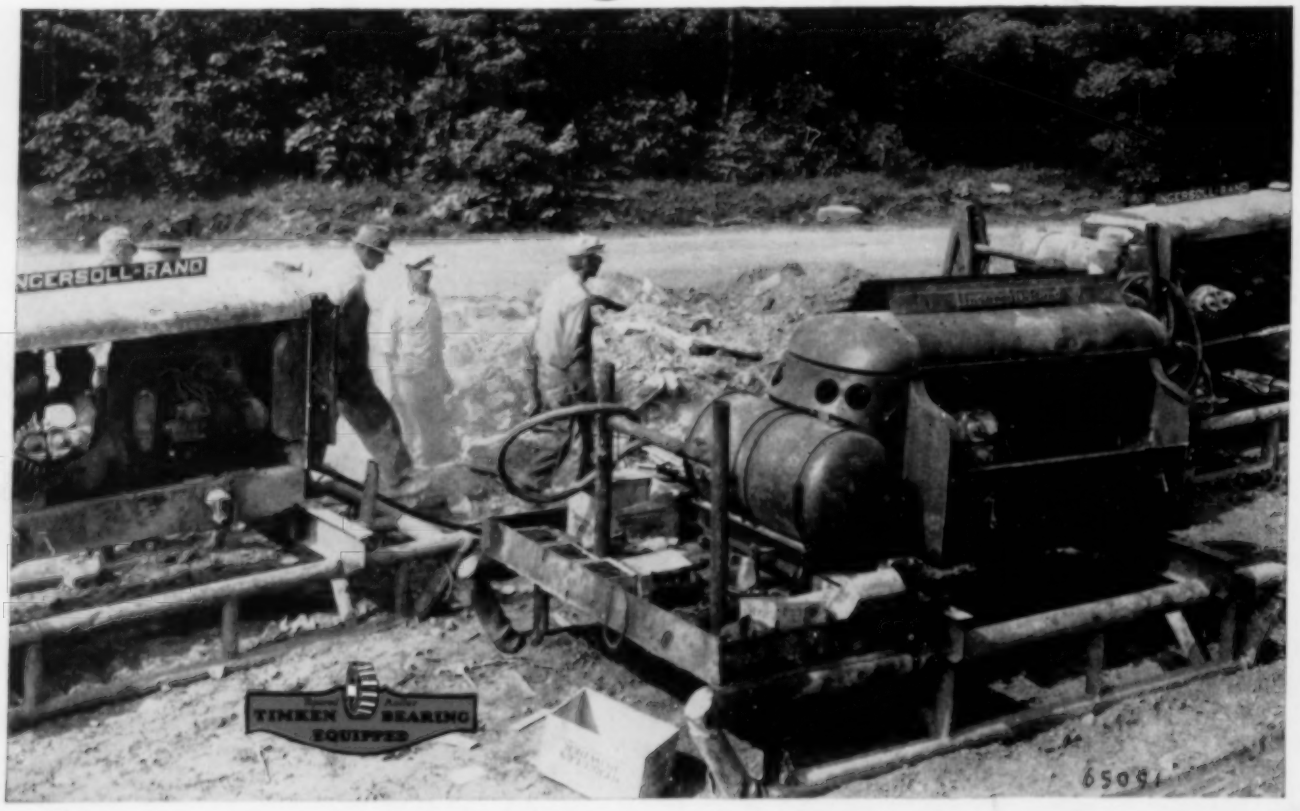
2-339

MOBIL-AIR
Compressors on the job

Press Association Inc. Photo

COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

AIR FOR THE "Big Inch" PIPE LINE



FROM TIMKEN BEARING EQUIPPED COMPRESSORS

Compressed air—and lots of it—was a necessity in laying the "Big Inch" pipe line, just as it is in most construction projects.

The photograph shows Ingersoll-Rand Type 40 Mobil-Air Compressors working on the O. C. Whitaker Company contract for the "Big Inch" line near Somerset, Pa. The compressors are shown on the special mountings designed and built by the contractor to facilitate skidding them along the line.

Like other types of Ingersoll-Rand Compressors, these Mobil-Air Compressors are equipped with Timken Tapered Roller Bearings on the crank shafts. This assures every anti-friction advantage, including smooth operation; prevention of wear on crank shafts; power saving; full protection against radial, thrust and combined loads; correct and constant shaft alignment.

To get all these benefits when buying anti-frictionized compressors of any type, specify "Timken Bearing Equipped". The Timken Roller Bearing Company, Canton, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

Get the edge on post-war competition now by redesigning your equipment to use more Timken Bearings.